SCOTTISH HOME AND HEALTH DEPARTMENT

The Future of the Artificial Limb Service in Scotland

Report of a Working Party set up by
the Secretary of State for Scotland

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Members of the Working Party

Mrs M. B. A. Denny, OBE, BA(HONS), PH D (*Chairman*)

Professor R. Barnes, CBE, B SC, MB, CH B, FRCS(ENG), FRCS(ED), FRCS(GLAS)

*G. D. Forwell Esq., MB, CH B, PH D, FRCP(ED), DPH, DIH

R. D. R. Gardner Esq., ACIS

G. Hay Esq., MB, CH B, FRCS(ED)

Professor R. M. Kenedi, B SC, PH D, ARCST, C(ENG), FI MECH E, AFR'AE S, FRSE

D. W. Lamb Esq., MB, CH B, FRCS(ED)

W. Michie Esq., MBE, MA, MB, CH B, FRCS(ED)

G. Murdoch Esq., MB, CH B, FRCS(ED)

G. Robertson Esq.

D. C. Simpson Esq., MBE, B SC, PH D, FRSE

G. A. Whitefield Esq., FRCS(ED), LRCP, LRCS(GLAS)

H. Miller Esq., MD, DIH (*Medical Secretary*)

Miss M. H. B. Brown (*Lay Secretary*)

* Dr Forwell succeeded Dr I. M. Macgregor, MD, DPH, FRCP(GLAS) in December 1967

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REPORT

Chapter **1** Introduction

1 We were appointed as a Working Party by the Secretary of State for Scotland in October 1967 with the following terms of reference:

> 'To review the artificial limb service in Scotland including the method of supply and fitting of artificial limbs, and to advise the Secretary of State on the future development of the service.'

2 To help us in our consideration of the subject we have obtained views on the artificial limb service, written and oral, from a wide spectrum of people and organisations connected with it. A list is given in Appendix A.

3 As well as having a full discussion at one of our meetings in Edinburgh with representatives of the Department of Health and Social Security, we visited their Artificial Limb and Appliance Centre and Biomechanical Research and Development Unit at Roehampton to see at first hand the facilities available and the work being done there.

4 We also arranged for an Organisation and Methods study of a limb-fitting centre to be carried out by the Management Services (O & M) Scottish Branch of the Civil Service Department so that we would have available to us some objective views on the organisation of the service. The report is reproduced in Appendix B.

5 We were given to understand that very good prosthetic services exist in Denmark and Sweden and as these countries are roughly comparable in terms of population numbers with Scotland, we felt we should see for ourselves how the services there were operated. Six of our number, along with the O & M officer who had carried out the survey for us, therefore visited Denmark and Sweden in March 1969. A report of this visit is given in Appendix C.

6 We have had twenty-four meetings, all held in Edinburgh, but during the time we have been sitting as a Working Party various of our members have visited Canada, the United States, Denmark, Sweden, Germany, Holland, Yugoslavia and Eire in connection with the prosthetic services in these countries so that we have been kept in touch throughout our deliberations with developments abroad as well as in this country.

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7 We should like to express our grateful thanks to all the people who wrote to us giving their views on the artificial limb service, to all those who were kind enough to come and have discussions with us, and especially to the people in Denmark and Sweden who devoted much time and trouble to showing us their services, discussing ideas with us, and answering our many questions.

8 We also wish to record our appreciation of the help given to us, particularly in the preparation of Appendices E and K to this report, by Mr John Hughes, Senior Lecturer in Bio-engineering at Strathclyde University.

9 Finally we wish to thank our Secretaries, Dr H. Miller and Miss M. H. B. Brown of the Scottish Home and Health Department, for their invaluable help and support. The main burden of preparing for our meetings, drafting many and dealing with all our working papers, and arranging our visits abroad and elsewhere has fallen on Miss Brown. She has discharged her duties with admirable efficiency, firmness and good humour and we are deeply appreciative of her services.

Margaret B. A. Denny
Roland Barnes
G. D. Forwell
Robert D. R. Gardner
George Hay
R. M. Kenedi
Douglas W. Lamb
W. Michie
George Murdoch
George Robertson
David C. Simpson
G. A. Whitefield

Hugh Miller
Muriel H. B. Brown

THE BACKGROUND TO OUR REMIT

Chapter **2** The Present Service and its Origins

10 Before the inception of the National Health Service in 1948 artificial limbs were supplied free only to those who had lost limbs as a result of war service; other people who needed artificial limbs had to obtain them privately, although they might be helped to do this by voluntary bodies, friendly societies, or other agencies. Expertise in the public service on artificial limbs was therefore concentrated in centres administered by the Ministry of Pensions for the supply of appliances to disabled war pensioners; the artificial limbs supplied were, however, made and fitted by commercial firms under contract to the Ministry of Pensions.

11 When the National Health Service was set up the Ministry of Pensions undertook to provide limbs, on behalf of the Health Departments, to National Health Service patients as well as to war pensioners. This meant a fourfold increase in the number of patients, including a much higher annual number of new amputees.

12 In 1953, as a result of the Transfer of Functions (Ministry of Pensions) Order 1953 all the medical treatment functions of the Ministry of Pensions were transferred to the Health Departments, it being the expressed intention to integrate these into the National Health Service. In England and Wales the then Ministry of Health assumed the responsibility of administering all the services direct for the time being, but in Scotland the functions were integrated into the National Health Service immediately. Artificial limb centres have thus in Scotland since 1953 been a part of and been administered by the National Health Service; their medical and administrative staff are hospital employees in contra-distinction to the situation in England and Wales where the centres are still run direct by the Central Department and are staffed by civil servants.

13 The effect on the limb service in Scotland of the closer integration with other hospital services, particularly the orthopaedic service, has been widely recognised as beneficial. The problems associated with fitting artificial limbs and rehabilitating patients are closely akin to those in orthopaedic and other departments of the hospital service, and a closer link with these departments has brought a broadening of vision to the artificial limb service and an impetus to new developments and improvements in it.

14 In Scotland the service is provided from four main centres at Aberdeen, Dundee, Edinburgh and Glasgow, an additional centre set up at the Victoria Infirmary, Glasgow, in 1966 where lower limbs only are supplied, and a part-time centre at Inverness run in association with the Aberdeen centre. The numbers of amputees on the registers of the limb-fitting centres and the numbers of new patients fitted with artificial limbs in the last five years are shown in Appendix D (*see*, however, paragraph 71).

15 From the Scottish Home and Health Department's statistics of hospital in-patients we obtained details of the patients who had amputations in the year 1966 (other than amputations of fingers and toes). A check of these and other details against the limb-fitting centre records has revealed no unmet need for the fitting of artificial limbs among these patients and we think it reasonable to conclude that in Scotland all who need, and are able to use, artificial limbs now receive them.

16 When the service was first taken over the old Ministry of Pensions premises were used and the other services which had been provided from there, like the supply of invalid transport, continued to be linked with the artificial limb service. This situation continues at Aberdeen, Dundee and at the main Glasgow centre; in so far as patients attending the limb centres sometimes also qualify for invalid vehicles, there is some advantage in this arrangement. At Edinburgh, the invalid vehicle service was split from the artificial limb service when new accommodation for the latter was provided at Princess Margaret Rose Orthopaedic Hospital in 1965. The Glasgow and Dundee centres have also had new premises since 1953, a new building being erected for the Glasgow centre in the grounds of Belvidere Hospital, and an old infant hospital being adapted at Broughty Ferry for the Dundee centre. The Dundee centre is unique among Scottish, and indeed British, centres at the present time in having beds for in-patients provided as an integral part of its facilities, although some other centres have beds in adjacent hospitals which can be used.

17 A nucleus of medical staff from the Ministry of Pensions came over to the National Health Service in 1953, but since then surgeons in charge of centres have been recruited from among consultant orthopaedic surgeons interested in prosthetics who devote a varying number of sessions per week to the work; this has helped greatly in strengthening the link between the artificial limb service and the orthopaedic services. Support for the consultant in charge is provided by other orthopaedic surgeons, medical assistants, or general practitioners working part-time in the hospital service, the pattern varying from centre to centre.

18 The administrative and clerical staff of the centres are also employees of the National Health Service, a number having come over from the Ministry of Pensions. The limb fitters and the technicians who make up some of the limbs and carry out repairs and adjustments at the centres are, on the other hand, employees of the commercial firms who manufacture the artificial limbs under contract.

19 There are three contractors supplying artificial limbs in Scotland—Robert Kellie and Son Limited (a subsidiary of the Vokes group) who supply lower limb prostheses at all the centres in Scotland and who have their factory in Dundee, Charles A. Blatchford and Sons Limited who supply lower limb prostheses at the Belvidere centre in Glasgow and who have their factory in Basingstoke, and Ideal Limbs Limited (Steepers) whose factory is at Roehampton and who supply all the artificial arms at the Scottish centres.

20 Most amputations are carried out in general hospitals and it is often not until some time after the operation when the stump has healed that full consideration is given to fitting an artificial limb. Unless other complications supervene the patient is then referred to the limb-fitting centre for assessment for the fitting of an artificial limb. In only a few cases does it not prove possible to fit a limb; but, although the situation has improved in recent years, there are still a number of patients who could probably have been better fitted if the surgeon performing the amputation had consulted before the operation with the prosthetic surgeon on sites and techniques.

21 After amputation most patients remain in the hospital where the operation was carried out for at least three weeks and after that many are transferred to a convalescent hospital. From there they are taken by ambulance to the limb-fitting centre for the fitting of their limbs and for walking training sessions, and then taken back to the parent hospital or convalescent hospital.

22 In the case of leg amputations the patient is normally fitted first of all with a temporary pylon which enables him to become ambulant until his stump is mature and its dimensions stable. Once the stump is relatively stable—the time varies according to the age of the patient, the reasons for amputation, etc.—the patient is measured for a definitive limb. After the first definitive limb has been made, a second (duplicate) limb is supplied so that if one limb needs to be repaired the patient is not left without a limb. In the case of arm amputees no temporary prosthesis comparable to the pylon is supplied.

23 The traditional method of supply of artificial limbs is for the limb fitter at the centre, working under the direction of the prosthetic surgeon, to take measurements and/or make a cast of the patient's stump and to send these with the order form to the factory for the limb to be manufactured. When the limb has been completed it is returned to the centre for fitting on the patient and, if it is satisfactory, delivery to him; if it is not satisfactory it is returned to the factory for adjustment or remaking. In the case of definitive artificial legs there is at least one intermediate fitting in addition when the limb is sent in an unfinished state from the factory to the centre, tried on the patient, any adjustments required noted by the fitter, and the limb then returned to the factory, with any instructions from the fitter about adjustments, for finishing off. This process can take as long as ten weeks, including the time the limb is in transit between factory and centre. It must be recognised, however, that delay in supplying a limb can arise because the patient fails to attend at the centre for the fitting or delivery of it, because he is ill or for some other reason; apart from consulting the patient about dates and times of appointments, neither the centre nor the contractor has any control over this.

24 In an effort to speed up deliveries, more of the work, including practically all pylon-making, is now being done at centres (except at Inverness). The more straightforward artificial arms (about 90 per cent of the total number) for patients at Edinburgh, Dundee and Aberdeen are now made at the Edinburgh centre, and the limbs for arm amputees at Glasgow and Inverness made in Glasgow. Special contractual arrangements were also made in 1968 to achieve quicker delivery of the artificial legs which still have to be made and repaired at the factory; a high proportion of limbs, apart from the more complicated ones, are now being delivered within thirty calendar days or less.

25 Within the contract arrangements there are at present eighteen different types of artificial legs available with approximately ninety-three variations: for example, different types of feet, knee controls, knee locks and suspenders are available and can be prescribed by the prosthetic surgeons according to the needs of individual patients.

26 In the case of artificial arms there are, for adults, sixty-five different types available with a range of some eighty-seven appliances used for various purposes. Special appliances are also supplied when a patient's occupation or hobby requires this. There are fourteen types of artificial arms and seven appliances for children. Hands for children are still a problem as they have to be individually made and specially reinforced; this at present necessitates the hand being built on a 'one-off' basis and there is consequently some delay in supplying small hands.

27 The responsibility for the safety of the artificial limbs supplied by manufacturers normally rests with them and they therefore make their own arrangements for inspection of the limbs. Checks of a proportion of new and repaired limbs are also carried out at the factories or the limb-fitting centres under arrangements made by the Scottish Home and Health Department to ensure that the manufacturers have complied with the specifications in the limb orders.

Chapter 3 The Need for Change

28 It has become increasingly apparent that the system devised originally to provide limbs for a comparatively small number of war pensioners is not adequate for the much larger numbers of National Health Service patients. The patients are moreover of a different type: war pensioners when they lost their limbs were generally young men in otherwise good physical condition but the majority of National Health Service patients are elderly victims of peripheral vascular disease, the complications of which are the main reasons for limb amputation. In particular, the time taken to make limbs and thus the delay before people who have had limbs amputated can begin comprehensive rehabilitation—which is particularly critical for the elderly—have come under criticism, from inside as well as outside the Health Service. At the same time, technological advances and a new approach to the construction of artificial limbs are making better fitting of limbs and quicker production possible, but patients are not yet getting the full benefit of these advances (*see* Chapter 4 and Appendix E).

29 With the broadening of vision in the artificial limb service in Scotland has also come an increasing awareness of the good service given to amputees in some countries abroad and of new prosthetic developments there. Some of these developments are now being introduced into this country, such as the immediate post-operative fitting of artificial limbs (*see* paragraph 39 and Appendix F).

30 The birth of a number of limb-deficient babies as a result of their mothers having taken the drug thalidomide during pregnancy and the urgent need to develop for them artificial limbs which would give more practical help than conventional artificial limbs has also stimulated prosthetic development and increased international collaboration, the effects of which are being felt elsewhere in the artificial limb service. For these children the application of external power sources to operate artificial limbs became imperative (*see* Appendix G).

31 A critical appraisal of the whole service and a review of the arrangements for running it therefore seemed timely. This has been the task allotted to us.

THE SERVICE WE SHOULD LIKE TO SEE

Chapter 4 The Patient and the Team Concept in his Treatment

The Patient and Amputation

32 Where amputation is not carried out by the prosthetic surgeon it is of the utmost importance that there should be the closest liaison between the surgeon performing the amputation and the prosthetic surgeon. Though liaison exists in some areas, in general, closer co-operation would be of advantage. Because of the high proportion of amputations resulting from peripheral vascular disease, the need for liaison between surgeons treating such cases and prosthetic surgeons is particularly evident. Peripheral vascular surgery will obviate the need for amputation in a proportion of patients, and permit of amputation at a lower level in others; for the future, however, the reduction in the number of amputations because of improved vascular techniques is unlikely to do more than balance the increase in numbers which may be expected from an ageing population.

33 Though amputation may prove inevitable when medical treatment or restorative surgery has no more to offer, this need not signify that the patient can no longer pursue an active role within his community. Amputation can and should be regarded as part of a rehabilitative process, the removal of a diseased or damaged member to be followed by its replacement by a device, which, although never as good as a sound natural limb, at least gives reasonable pain-free function. The patient should be encouraged to look upon his situation in this way and where possible, his education should start before operation so that his fears are allayed and he can look to the future with confidence and assurance.

34 Ideally, we should like to see the patient transferred before operation to the charge of the prosthetic surgeon in the hospital of which the limb-fitting centre is part, where the patient can be encouraged by the progress of other patients. He would enjoy the advantages of continuing care and supervision by one medical adviser fully conversant with his needs at all stages in his treatment and rehabilitation. A planned routine of pre-operative physiotherapy would be available, including practice where appropriate in walking with a prosthesis, *ie* walking with a kneeling peg. Operation would be performed by an acknowledged expert in prosthetic surgery. Following amputation he would have the advantages of an established prosthetic service including new developments such as the

immediate post-operative fitting of artificial limbs which would normally be available only at hospitals with limb-fitting centres.

35 While we should prefer that amputation be carried out by the surgeon responsible for future prosthetic management, we are aware of the difficulties which may be encountered in achieving this. We suggest that in any event the patient should be seen in joint consultation by the two surgeons concerned wherever possible. In advocating this we recognise that, for example, the vascular surgeon has much to offer from his knowledge of the patient's peripheral arterial system. We hope that by mutual discussion the most appropriate technique and site of amputation will be determined. Where the operation has taken place outwith the prosthetic service the patient should be transferred as soon after operation as possible to a bed at the hospital of which the limb-fitting centre is part.

36 We are aware that the initiative in joint consultation must come from the surgeon performing the amputation and that nothing can be achieved without his co-operation. We are confident that an appreciation of this situation as we see it will develop by the gradual progress of medical education and communication between specialties (*see also* Chapter 9).

37 We have considered whether specialist amputation centres might be set up to which patients requiring amputation should be referred, but have dismissed the idea as impracticable and, indeed, undesirable. With the number of amputations performed, probably only one centre for the whole of Scotland would be viable and many patients would therefore have to be sent a considerable distance from their homes at a time when the support of relatives and friends can be critical. Many patients requiring amputation, moreover, also suffer from other conditions for which the continuing care of other specialists is required.

38 In any event, all limb-fitting centres should have in-patient beds closely associated with them. These should be of three types:

(*a*) beds for patients requiring full nursing care:

(*b*) beds for patients past the immediate post-operative phase who are having limbs fitted and learning to use them and who can look after themselves to some extent; these beds should be of the minimal care category but should nevertheless be close to the wards and to the limb-fitting centre: and

(*c*) hostel beds for established amputees coming in for replacement limbs or major repairs, whose homes are at distance from the centres, or for amputees who are being fitted with a different type of limb and require training in its use.

Provision of such beds at or in close proximity to the limb-fitting centre will, moreover, as well as benefiting the patients, save the time and money of transport by avoiding the recurring journeys between the centre and the general or convalescent hospitals in which most patients are accommodated under existing arrangements.

39 We have referred to new techniques now becoming available in the artificial limb service in Scotland, such as the development of the immediate post-operative fitting of artificial limbs. This is a technique for fitting patients with a temporary prosthesis whilst still on the operating table after amputation (*see* Appendix F); it offers considerable advantages for some patients in that they quickly become ambulant, but it demands a high standard of limb fitting and the availability of workshop facilities so that the prosthesis can be fabricated and any subsequent adjustments to it made quickly. A team of surgeon, prosthetist, physiotherapist and nursing staff who are accustomed to working together is essential to the success of the technique. It must therefore be performed at a hospital which incorporates a limb-fitting centre.

40 The team concept is indeed, we are convinced, the basis of satisfactory working in the prosthetic service of the future. The nature of the team will change according to the patient's varying needs and will include from time to time, as well as the people mentioned above, a medical social worker and an occupational therapist; representatives of supporting social services, bio-engineers and medical physicists may also be called in as required. If amputees are to be rehabilitated as fully as possible then all their circumstances, and not merely their immediate medical needs and the type of artificial limb required have to be considered; to do this effectively, the combined skills of all the members of the team are required, although all of them are not necessarily involved all the time. Before prescribing an artificial limb for instance, the prosthetic surgeon may need advice from the medical social worker on the patient's job and home circumstances as well as advice from the prosthetist on suitable limb mechanisms (*see also* paragraph 73).

The Patient and his Artificial Limb

41 Satisfactory rehabilitation of patients also requires the proper fitting and quick delivery of prostheses. It is only when his first limb is fitted and begins to be a part of him that the patient can feel that he is playing an active role in his rehabilitation; if he is frustrated in doing this by slow delivery of the limb then the efforts of surgeons and others are largely wasted. Proper fitting and quick delivery of limbs are thus of paramount importance.

42 An artificial leg comprises, basically, a socket which is highly individual plus a foot, leg pieces, ankle and knee mechanisms etc. which vary in size, number and type according to the height and build of the patient and the level of amputation. We consider that the logical way to build an artificial leg is to make the socket where the patient is and then to add to it the appropriate pieces of hardware taken from the stock of components in the centre to make up an artificial leg of the type required. The leg can then be tried on the patient, evaluated, and any changes required for fit, alignment or function made immediately. If modern concepts and techniques are adopted it is possible to select the parts required from a range of pre-manufactured, interchangeable, standardised components, which should be made according to modular principles (*see* Appendix E).

43 An artificial arm can similarly be made up quickly at centres from component parts and there should be no cause for delay in supply.

44 A limb made up under the immediate supervision of the prosthetist who fits it, is much more likely to have the individual socket characteristics which the prosthetist knows the patient should have. Delivery times can also be adjusted to suit the patient's needs; when necessary a limb can be produced in twenty-four hours, but overall production can be geared to meeting varying priorities.

45 If moreover the prosthetic team, after watching a patient trying out his limb, think that he might be better suited with, say, a different type of knee or elbow mechanism, then a different mechanism can readily be substituted if the limb is of modular construction and made up on the limb centre premises. Several variations of mechanism can indeed be tried until the most suitable one to meet the patient's need is found. Once the right components and alignment have been determined a cosmetic fairing can be added to the limb.

46 Repairs to limbs made up in this way can be readily carried out at centres by the replacement of defective parts, thus obviating the delays which patients find so handicapping and irritating. With quick repair facilities it may be possible in some cases to save the expense and trouble of issuing duplicate limbs, which may never be worn.

47 We set out what we consider to be the essentials of a modular system for the construction of artificial limbs in Appendix E. At the present time when modular systems are being developed throughout the world the opportunity exists to secure international co-operation on the required levels of static and dynamic performance for modular limbs and on the standardisation of physical dimensions, particularly those of interfaces. Without international agreement a modular system of construction of limbs will still be a significant advance on present methods but if components from different systems can be interchanged then the advantages will be that much greater. We therefore strongly recommend that arrangements be initiated without delay to try to secure international co-operation.

The Patient and Rehabilitation

48 Once having got his artificial limb a new amputee cannot simply walk away wearing it. He requires training and practice in using it. If he is a leg amputee, he obviously wants to learn to walk, but this involves much more than a slow progress up and down between parallel bars. In everyday life the patient will have to go up and down steps and gradients and walk on different types of surfaces, to sit down and rise, to fall and get up again. An arm amputee has to re-learn how to carry out his own toilet, to feed himself, to write and to perform the functions required in his job and in his hobbies or pastimes. For him, a variety of appliances is available, from special nail-brush holders to spade-grips, and he should have an opportunity to try out and practise using any of these which can help him. (If, however, a good functional hand can be developed the need for separate appliances could perhaps be obviated). Any amputee, whether lower or upper limb, will also be using other parts of his body in ways he has not had to do before to compensate for the limb he has lost and will need exercises and training in how to do this. He should, of course, learn how to put on and take off his artificial limb himself and how to keep it clean and look after it.

49 Facilities for all these activities must be provided at centres and amputees should be able to live in accommodation associated with the centres (*see* paragraph 38 above) until they are reasonably proficient in using their limbs. In suitable cases attendance as an out-patient may be sufficient.

50 Some amputees of working age may be able to resume their old jobs, but, if not, they must be helped to find new work. Resettlement in employment with retraining where necessary is the function of the Department of Employment and Productivity, and it is important that the advice and guidance of the Disablement Resettlement Officer of that Department should be sought at an early stage so that rehabilitation can be effective.

51 No matter how successfully rehabilitated, however, amputees continue to need some help from the prosthetic service throughout their lives as their artificial limbs periodically have to be repaired and replaced. There may also be stump changes requiring renewal of sockets. Many patients do not of their own volition come back to the limb centre until some major mechanical breakdown or other problem forces them to do so, but with earlier surveillance the serious trouble which may then ensue can perhaps be avoided. Patients should therefore be encouraged, through a regular recall notice, to return to centres periodically for a check-up; they should also have explained to them the arrangements for repair of limbs. When the patient attends for this check, he should be seen by all the relevant members of the prosthetic team so that not only can the condition of his prosthesis and its fit be checked but he can also be advised on postural and other faults which he may have developed in using it, or in any other problems of daily living or employment which he may have as a result of being an amputee.

Chapter 5 Organisation of Limb-fitting Centres

Location

52 For the patient, the nearer a limb-fitting centre is to his home the better. When he becomes an amputee and is having his first limbs fitted he requires to be there for substantial periods. Later on, he will almost certainly have to return at some time for major repair to or replacement of his artificial limb and even when minor repair is needed it is more convenient if he can take the limb himself instead of having to send it by post. These considerations suggest the greatest possible decentralisation.

53 Modern prosthetic techniques however require a degree of expertise which is obtainable only from people with specialist experience; such people are scarce and so the most economic use must be made of their services. Expensive equipment and facilities are needed and must be fully utilised if the cost of providing them is to be justified. To enable future staff to be trained and existing staff kept up to date, it is also desirable to have a concentration of patients, experts and facilities. This suggests greater centralisation.

54 Completely to satisfy these two opposing needs is impossible. And the expedient of mobile facilities and itinerant staff is not practicable as the time spent in travelling reduces the time which can be spent with patients. A compromise is therefore necessary and we have concluded that there should be one limb-fitting centre in each Hospital Board Region in Scotland, with possibly two in the Western Region, *ie* more or less the same distribution as at present. We have considered the viability of the centre at Inverness but because of the wide geographical area it serves and the increased distances which patients from the Northern Region would have to travel if it did not exist, we consider that its continuance is justified.

55 If, however, following the recommendations we make in Chapter 11, the orthotic service (*ie* the service for the provision of orthopaedic appliances) and the prosthetic service are linked, it may be possible to arrange for repairs to artificial limbs to be carried out at orthopaedic workshops where these are nearer to patients' homes than the limb-fitting centres. The situation at Inverness would also become easier.

56 A limb-fitting centre should ideally be part of a general hospital so that close links can be maintained with the departments of orthopaedic and vascular surgery, and with the rehabilitation unit.

Facilities Required at Limb-fitting Centres

57 A limb-fitting centre requires facilities for:

(*a*) the medical examination and assessment of patients;

(*b*) measuring patients for their artificial limbs and taking casts of stumps;

(*c*) making, adjusting and repairing artificial limbs including socket construction;

(*d*) fitting limbs on patients, including the static and dynamic alignment of the limbs;

(*e*) training patients how to use their limbs and general rehabilitation of the patients;

(*f*) accommodating patients who require varying degrees of care until they are ready to go home with their artificial limbs, or patients whose homes are distant from the centres who come in for repair to or replacement of their artificial limbs or possibly further training in using their limbs (*see also* paragraph 38).

In the design of the whole centre account must be taken of the needs of patients in wheelchairs.

58 (*a*) and (*b*) usually occur consecutively on the same day. For (*a*) the prosthetist, physiotherapist and medical social worker should normally be present as well as the surgeon; (*b*) will probably require a prosthetic technician as well as the prosthetist.

59 (*c*) requires a prosthetic workshop including appropriate facilities for working in plastic and suitable storage for the stock of components which will be required. A small receipt and despatch department for dealing with limbs sent in for repair by post should be included.

60 For (*d*) a fitting room with a walk-path and adjustable rails for the patient is needed; the walk-path must have a straight run of at least 30 ft (10 metres) to allow adequate examination of gait. Not only will the surgeon and physiotherapist be present as well as the prosthetist and prosthetic technician but clinic conferences will also be held in this area and so enough space is required for all the people likely to attend. Facilities for making notes and records will also be needed.

61 We have already referred in paragraph 48 to the wide scope of activities which we consider should be included in the training and rehabilitation of the patient referred to at (*e*) above. Patients generally take great encouragement from group therapy but there must be adequate gymnasium and therapy workshop space for this. An outdoor area where patients can practise walking over hard, soft or rough ground and up and down slopes should be included. Provided these facilities are adequate they could be shared with other hospital departments. They should, however, be adjacent to the limb-fitting centre because of the ambulation problems of amputees and also because the patients need to be visited during training by surgeons and prosthetists as well as physiotherapists; it may also become apparent during training that some adjustment is needed to an artificial limb and it is desirable for this to be done on the spot.

62 For (*f*) we suggest provision of five to ten full nursing care beds and a total of ten to fifteen minimal care and hostel beds for every half-million population served by the centre; for centres with a high proportion of patients who travel long distances the scale of hostel bed provision may have to be greater. We have based these figures on the assumptions that all new leg amputees will need a total of nine weeks in-patient care; leg amputees who have had conventional amputations will require three weeks in the nursing care beds and patients undergoing immediate post-operative fitting of artificial legs a further two weeks; for the remaining time these patients should be able to occupy minimal care beds. New arm amputees, who represent about ten per cent of the total number, will, we consider, need one to two weeks in full nursing care beds, after which, if circumstances are suitable, they can be discharged home for three to four weeks until the stump characteristics have stabilised; thereafter they should return for one to two weeks rehabilitation and prosthetic training during which time they can be accommodated in minimal care beds unless it is convenient for them to attend as out-patients. We suggest that pilot schemes will be necessary finally to establish the right numbers and proportions of full care, minimal care, and hostel beds. Some of these beds will enable beds in other hospitals to be released.

63 Other features of an out-patient department such as a reception area, undressing facilities for patients, toilet facilities and a patients' waiting area, with a snack-bar, will be required, it always being borne in mind that a higher proportion than normal of the patients will be in wheelchairs. We hope that with good organisation unnecessary waiting can be minimised but there will be periods when it is necessary—and indeed desirable as an alternative to a return visit—for a patient to wait for several hours, say, for an adjustment or a repair to his prosthesis.

64 We also recommend that a suitable conference cum lecture room be available. It should have facilities for demonstrations and showing slides and films.

65 The need for space and facilities for research and development work must not be overlooked (*see* Chapter 10).

66 The number and size of all these facilities which we have mentioned and their juxtaposition to each other should, we consider, be the subject of a detailed study on the lines of the investigations made by the hospital planning team of the Scottish Home and Health Department before they published their Planning Note No. 6 on Organisation and Design of Out-Patient Departments. We therefore suggested to the Department that such a study should be undertaken and they have put arrangements for this in train. In the study we recommend that account be taken of the recommendations on the lay-out and equipment of a large limb-fitting centre contained in the World Health Organisation Technical Report Series No. 100 and of the detailed guidance on the subject in the paper presented by Mr Erik Lyquist to the United Nations Inter-Regional Seminar on Standards for the Training of Prosthetists and Orthotists in Holte, Denmark, in July 1968.

Transport of Out-patients to Limb-fitting Centres

67 One of the major problems of organising clinics at limb-fitting centres, especially at the larger centres, has hitherto been the delivery of patients at the right time for their appointments. We urge that transport arrangements either by ambulance or by mini-bus as suggested below should be so organised as to make possible the proper operation of an appointments system with all the benefits of economy and convenience which this implies.

68 Traditionally patients have been transported to centres by ambulances but we doubt if this is the most appropriate vehicle for patients who, though not fully ambulant, are sitting up. We were impressed by the use made in Denmark of mini-buses to transport amputees, and we recommend that vehicles of this type, suitably adapted if necessary, should be provided in Scotland. We have indeed already put forward this suggestion to those carrying out a survey at the present time into the operation of the ambulance service.

Appointments System

69 We certainly think that a well-run appointments system is important both for patients and for staff, and we are sure that if the centres have control of limb-making and if patient transport is properly organised then the present arrangements can be much improved.

Documentation

70 The present system of supply of artificial limbs involves complex documentation in ordering and accounting; with the new arrangements for limb-making which we propose, we expect that this documentation can be greatly reduced. On the other hand new duties will emerge in ordering component parts for artificial limbs and in stock-keeping.

71 Both the information given to us following the O & M Survey which we commissioned at one centre and our own experience indicate that there is room for considerable improvement in the keeping of patients' records and statistics. We have ourselves made strenuous efforts to collect reliable and relevant statistical data but have been able to obtain only the information presented in Appendix D, in the introduction to which we give a brief summary of our attempts to extract the statistics which we wanted. As a consequence of our experience we strongly recommend that a study be undertaken by the Scottish Home and Health Department, in co-operation with the hospital service, to determine how reliable records of amputations and limb provision can best be made available in the future. A good statistical basis is essential for the rational implementation of many of our proposals: its development is undoubtedly dependent on the existence of an adequate and efficiently organised administrative service at the limb-fitting centres, to which we draw attention in Chapter 6.

Chapter 6 Staffing of the Limb-fitting Centres

72 We do not think it appropriate to make firm recommendations on the staffing of individual limb-fitting centres, but we suggest guide-lines. In a country like Scotland no one centre is exactly like another; the type of area they serve, the work other than straightforward prosthetics carried out, and the relation of the centre to other parts of the hospital service vary from area to area and the staffing needs vary accordingly.

73 As we have already indicated (paragraph 40) we consider that a team comprising prosthetic surgeon, prosthetist, physiotherapist, occupational therapist, medical social worker and nursing staff is necessary for the satisfactory treatment and rehabilitation of amputees. The whole team is not required all the time but each member has an important part to play at different stages of the patient's treatment. The team should, however, have regular clinic conferences which all the members attend, where the treatment of individual patients can be discussed as well as matters of general policy, new developments in the prosthetic field, and new problems which may arise. Other people such as the Disablement Resettlement Officer of the Department of Employment and Productivity and the representative from the local authority's social work department should be present for these conferences when appropriate. When new or complicated problems in limb-fitting are being considered, bio-engineers and/or medical physicists will also be involved.

Medical Staff

Consultants

74 The person in overall charge of the limb-fitting centre and the leaders of the clinic teams should be consultants with special knowledge and experience of amputation surgery, bio-mechanics and prosthetics. The success of the prosthetic service in Scotland since it became part of the orthopaedic service suggests that these roles are most appropriately filled by orthopaedic surgeons, and some of our other recommendations are therefore made in the context that the consultants will have commitments elsewhere in the orthopaedic field. We consider it important for the consultants to have these other commitments, because prosthetics is a narrow specialty and we believe that most consultants would not wish to devote their full time to it; normally not more than four sessions per week would in our view be the appropriate time but in special circumstances this might be increased.

75 Consultant cover should be provided at all times when clinics are being held at centres, and so additional part-time consultants will require to be appointed. These additional consultants could with advantage be drawn from different orthopaedic units in the catchment area of the limb-fitting centre; this may entail the appointment of additional staff at these units but each unit will then have the advantage of having someone readily available to advise on amputations and prosthetics, and to help in training registrars and others.

76 The consultants' duties will include amputation surgery, medical prosthetics, prosthetic research, prosthetic education, and administration, the amount of time devoted to each varying according to the needs of each centre and the interest of individual consultants.

Supporting Medical Staff

77 As not all of the medical work associated with prosthetics requires the attention of a consultant there should be adequate supporting medical staff. Because of the time taken to acquire a sufficiently comprehensive knowledge of prosthetics, and in the interests of continuity, this staff should not be in a training grade. The appointments may be full-time or part-time according to the needs of the centre. A fruitful source of recruitment is among general practitioners interested in prosthetics, particularly those who have at some time had training in orthopaedics.

78 In addition to their prosthetic work the supporting staff may exercise the day-to-day care of in-patients occupying the beds which we recommend elsewhere in this report should be associated in future with all limb-fitting centres. (Paragraphs 38 and 62.)

Amount of Medical Time Required

79 The amount of medical time devoted to prosthetic work in Scotland at present is approximately 1400 sessions per annum. With 10,000 patients on the registers, however, clinic sessions at some centres are so large that the medical staff are not able to devote to each patient the time necessary for satisfactory limb-fitting. This situation is frustrating for the surgeons and less than fair to patients.

80 A considerable increase in the total medical time devoted to limb-fitting is therefore necessary and we consider that the number of sessions for Scotland as a whole should be raised to about 2000 per annum for basic prosthetic work by medical staff. How this figure has been worked out, how it should be applied for individual limb-fitting centres and how it should be augmented for duties associated with but additional to basic prosthetic work are set out in Appendix H.

Prosthetic Staff

Prosthetists

81 As modern prostheses become more sophisticated and standards of fitting improve, more and more is demanded of the limb-fitter. We therefore consider that he should in future be accorded professional status as a prosthetist, taking all the responsibility which such status implies and having the training necessary to enable him to do so. We have prepared a detailed description of the job as we see it, and this description is reproduced in Appendix I. We have also made detailed recommendations in Chapter 8 on the training of prosthetists in the future. Unlike the medical staff, prosthetists will be engaged full-time.

82 The number of prosthetists required is related to the number of patients, and the standard of service given. Experience elsewhere in the world suggests that the majority of centres need at least one prosthetist for every 300 patients on the amputee register. Our own experience and that of others suggests that the minimum time required per patient for measuring, casting, rectification, fitting and checking out should be not less than 2½ to 3 hours; taking these times, and making allowance for prosthetists' other duties such as limb repairs, research and development work, administration and training and their holidays and sick leave, leads us to support the ratio quoted above. We conclude that the number of prosthetists required for Scotland is about forty.

Prosthetic Technicians

83 As we envisage all limbs being fabricated locally on the premises of the limb-fitting centre under the direction of the prosthetist, he must be supported by an adequate number of properly trained prosthetic technicians. For a time there may also be a need to deal with major or minor repairs for existing conventional limbs.

84 We have therefore also prepared a 'job description' for prosthetic technicians and this is reproduced in Appendix J. Suggestions on their training are included in Chapter 8.

85 In the absence of experience of this field on a large scale we are not in a position to recommend a ratio of prosthetists to prosthetic technicians but ratios ranging from 1:5 to 1:12, depending on the method of production of limbs, have been quoted from centres abroad. While prosthetic technicians would be responsible in the majority of centres for covering the range of processes involved in fabricating a limb, it would also be possible in large centres for a technician to specialise in certain processes or the use of certain materials.

Therapists

86 Attention has been drawn elsewhere to the need for adequate physical and occupational therapy treatment for both in-patient and out-patient amputees. If, as we recommend, limb-fitting centres are part of general hospitals the therapists will no doubt be drawn from the main physical and occupational therapy units of the hospital; the staff of these units would therefore have to be increased appropriately. Therapists working with amputees will, however, need specialised training for this work. We find it difficult to recommend an appropriate ratio but experience suggests that at least one physiotherapist for every 700 patients on the amputee register is required.

87 The services of an occupational therapist will also be required at all centres, in particular for upper limb amputees.

Medical Social Workers

88 Despite all that can be done by way of limb-fitting and training to help amputees, considerable rearrangement of their way of life may be necessary and the services of a medical social worker are therefore needed to advise on this aspect of rehabilitation and to make and maintain contact with agencies who can provide or arrange for the practical or material assistance required.

Nursing Staff

89 The numbers and types of nurses required for in-patient care will relate to the needs of the patients which will vary from a high degree of nurse dependency to self-care. It is recommended that the staffing arrangements which apply to an out-patient department in a general hospital should be the basis for staffing an out-patient prosthetic unit.

Other Staff

90 There are also other members of the staff of the limb-fitting centres who are essential for the smooth running of the prosthetic service. They include administrative and clerical staff, secretaries and porters.

Administrative and Clerical

91 Assuming that the recommendations we make elsewhere in this report are adopted, the work of limb-fitting centres will be very different from the present and although we commissioned an Organisation and Methods Study of one of the centres (*see* Appendix B), it is difficult to say how many administrative and clerical staff will be required and what their functions will be. It is, however, clear that considerable redeployment of the existing administrative and clerical staff will be needed. We suggest that in the initial stages of introduction of the new arrangements a flexible attitude be maintained and that the administrative and clerical staffing be reviewed after the new arrangements have become fully operational.

Secretarial

92 Centres vary widely at present in the amount of secretarial help given to the medical staff, but it should be appreciated that to provide inadequate or inexperienced help results in waste of expensive medical time. The senior prosthetist at each centre may also require secretarial help. We expect that dictating machines will be used when practicable but we strongly recommend that in the interests of overall efficiency each centre should have a realistic establishment of secretaries and typing staff.

Porters

93 Transportation of non-ambulant patients is an important function within the confines of a limb-fitting centre. At present much of this work is done by clerical staff and by auxiliary nurses but we consider it important that in future each centre should have the services of porters, the numbers depending on the numbers of clinics and the layout of the centre.

Chapter 7 The Future of Prosthetists and Prosthetic Technicians

94 In Chapter 4 (paragraphs 42 and 43) we describe a concept of limb construction where the limb is composed of a number of standard parts, the particular parts being used in any individual case depending on the needs of the patient. It is envisaged that all makes of any components, *eg* knee mechanisms, will be fully interchangeable (with the use of adaptors where necessary).

95 One result of the adoption of this approach would be the exclusion of the factory from the fabrication of the complete limb and the role of the factory would become that of a supplier and possibly reconditioner of parts of limbs rather than of complete and finished artificial limbs. Their efforts would then be directed towards the production of the most satisfactory components to specification and the control of the standards of manufacture. Several manufacturers might be involved in supplying the different components for any one limb.

96 The initial assembly of the parts and any subsequent change in the prescription of the limb would be carried out by the prosthetist in the limb-fitting centre under the guidance of the prosthetic surgeon and the former's association with the factory would become that of a receiver of parts rather than the agent of any particular manufacturer. The prosthetist would no longer be involved as an intermediary in a factory process of limb fabrication.

97 One of many benefits to the patient which would be obtained by this system would be that the timing of the delivery of the limb, as well as its construction, would be under the control of the prosthetic surgeon who could readily, through the prosthetist, alter priorities to meet individua cases. This underlines the point, however, that the relationship of th prosthetist to the prosthetic surgeon would be similar, under the new circumstances, to the previous relationship of the prosthetist to the contractor and the factory and the reason for the prosthetist's attachment to the factory would cease to exist.

98 In addition, all the groups of staff whose duties are described in the preceding chapter are employed by the National Health Service except prosthetists and prosthetic technicians. This in our view creates a position inhibiting to the full development of the clinic team concept, which we regard as fundamental to the future of the service.

99 Prosthetists are key members of the team and their identity with its aim and procedures should not be open to any conflict of allegiance or interest, either between manufacturer and surgeon, or between different manufacturers. We believe that they should have professional status, that they should be fully integrated into the work of the hospital, and for this reason we recommend that they should be brought into the National Health Service on suitable terms and conditions as soon as possible. Grades commensurate with their responsibility, *eg* managerial, teaching or research, should be established.

100 Prosthetic technicians at the centres, who work so closely with the prosthetists, should also become National Health Service employees so that they too can play their part in the work of the clinic team and enjoy their proper status working for the benefit of disabled people.

Chapter 8 The Education and Training of Prosthetists and Prosthetic Technicians

101 The relationship between prosthetist and patient is similar to that between doctor and patient. After operation the primary emphasis in the rehabilitation of the patient shifts to the prosthetist; he is responsible for achieving the best possible integration of the prosthesis with the complete body mechanism of the patient and to effect this he must be able to obtain the confidence of his patient and the other members of the clinic team. He must be able to follow and develop new advances in prosthetics, adapting these to the needs of his patients, and equally important, be able to inform and even lead his clinical colleagues in matters pertaining to his specialty. He must be of suitable personality and must at all times be aware of the long-term implications of the procedures he is initiating. In short he must be capable of assuming professional responsibility.

Training Required

102 To enable him to do this he needs proper training. We visualise this as embodying a good grounding in the basic physical and life sciences, and their application to clinical practice, together with liberal and technological studies.

103 Broadly we regard the course as having four major aspects:

(*a*) basic sciences (*eg* mathematics, materials science, mechanics and biology);

(*b*) clinically orientated applied sciences (*eg* anatomy, physiology, biomechanics, pathology and an introduction to clinical medicine);

(*c*) advanced studies consisting of the relevant scientific topics—studies on a narrow front but in depth specifically related to prosthetic function (*eg* body dynamics and control, the body/prosthesis interface problem); and

(*d*) liberal studies, namely, topics necessary to provide the broad educational background mandatory for professional status (*eg* communication, elements of applied psychology, the social aspects of rehabilitation, and an introduction to the principles of management).

104 We consider it of some importance that an integrated approach should be maintained in the presentation of the academic content, especially in the clinically based scientific teaching where the different subjects should be taught in relation to whole body systems.

105 The instructional courses should be supplemented by seminars, practical laboratory and clinical work covering subjects such as gait analysis, amputation surgery, prosthetic prescription and rehabilitation training.

106 It is important that trainees should be introduced to the clinical scene at the beginning of the curriculum and that clinical education should be gradually expanded as knowledge and experience is acquired and as the professional responsibilities become clearer to the trainee.

107 While we do not wish to recommend a specific detailed curriculum which might preclude desirable variations within the general principles outlined, we have prepared for guidance details of a specimen course (*see* Appendix K).

Organisation of Courses

108 We recognise that the introduction of the course and its format is closely related to the number of potential candidates. There are probably three main sources of recruitment—from Scotland, from other parts of the U.K., and from overseas, particularly from the developing countries.

109 As we indicated in paragraph 82 the number of prosthetists likely to be needed in Scotland is about forty. This can be met in part by upgrading the present limb-fitters, some twenty in number, but the other posts will have to be filled by new recruits. It will be four years before the first of the new recruits complete their training, inevitably a few may fail to finish the course, and in the meantime there will be wastage due to retirement or other reasons among existing fitters; to build up to the number of forty within eight to ten years therefore, six candidates will have to be recruited each year from Scotland alone. Even if no other recruits come forward from outside Scotland, six candidates would, we consider, be sufficient to justify the institution of a training course, certainly in the short term. (We comment on training requirements in the long term in paragraphs 117 and 118.)

110 Some of the subjects which must be included in a training course for prosthetists are also obligatory in training courses for other para-medical professions and we therefore recommend that training programmes should be correlated and facilities shared with these other professions wherever possible. The shared programme could take the form of a common 'core' covering some of the more basic academic subjects. The extent of the common core would vary depending on the professions associated; the shared element in the training of occupational therapists and prosthetists would for instance be minimal but between orthotists (workers engaged in the orthopaedic appliance field) and prosthetists would amount to virtually three-quarters of the total course. Such integration of paramedical training programmes would ensure the viability of courses by enabling the most economic use to be made of training resources. Our proposals have therefore been drafted in a form amenable to integration in this way. There is, however, one proviso we would make relating to the size of the practical and clinical classes; experience abroad (discussion at the United Nations Inter-Regional Seminar on Standards for the Training of Prosthetists and Orthotists in Holte, Denmark, in July 1968) indicates that the optimum number for effective teaching in such classes is about twelve with a maximum of eighteen.

111 As prosthetic practice develops the knowledge of practising prosthetists will have to be continuously upgraded to the accepted standards of the day, and we therefore consider that short- and long-term extension courses will be necessary.

112 In view of the foregoing we recommend the creation of a Course Centre attached to or near a limb-fitting centre and major hospital, and with University (or College) teaching facilities available.

113 For the teaching of the academic programme we recommend that the services of appropriate specialists already concerned with prosthetics be utilised in the first few years, even if this means that they have to travel from one part of Scotland to another. Located as they are in Aberdeen, Dundee, Edinburgh and Glasgow travel will not be unduly burdensome for the restricted period envisaged, and the arrangements will have the advantage that these specialists, being already in the field, will transmit their own sense of commitment and enthusiasm to the students. It will also have the advantage of allowing a permanent staff at the Course Centre to be built up gradually by selecting potential local tutors and training them alongside the prosthetist students in the initial years.

114 While the academic programme visualises the trainee based at the Course Centre and the staff in the initial stages mobile, the reverse procedure seems more suitable for fulfilling the practical programme. Along the lines of sandwich training long established in technology, students in appropriate groups should, we think, be sent to different Scottish limb-fitting centres for their practical training. The detailed arrangements and the supervision of the practical programme would be the joint responsibility of the Course Centre and the senior prosthetist at the particular limb-fitting centre selected for the students' practical training.

Payment of Trainees

115 Trainee prosthetists recruited for posts in the National Health Service could be paid grants as students during their first years of training, or alternatively they could become National Health Service employees and be paid a salary from the beginning of training. There are virtues in both methods, but we prefer the latter, as a trainee prosthetist who is an employee of the National Health Service will have a stronger sense of loyalty and commitment to the Service.

116 Students supernumerary to the national recruitment requirements, for example from overseas, could be required to meet the expenses of their training from other sources (*eg* private resources, grants, fellowships).

Prosthetic Training in the Long Term

117 We have put forward in the preceding paragraphs the case for the establishment of a Course Centre related to the relatively short-term requirements of the initial phase (some ten years) of the development of a professional prosthetic service. Once past the initial phase there will be a decrease in the numbers of National Health Service candidates, but we foresee a growing demand for training from other sources, *eg* students from overseas.

118 The long-term continuous commitments of the Centre might therefore be as follows:

(*a*) *Courses*

(1) to offer post-graduate training to doctors and to other paramedical staff concerned with prosthetics;

(2) to maintain and extend the professional competence of practising prosthetists in relation to change in established techniques, new techniques and associated developments;

(3) to offer opportunity to established prosthetic and orthotic technicians to reach professional level as prosthetists;

(4) to train future instructors in prosthetics;

(5) to enhance and maintain awareness of current research and its clinical applications.

(*b*) *Development*

of teaching publications, applied research programmes and information exchange.

Certification of Prosthetists

New Recruits

119 The culmination of the course for prosthetists must be the award of a certificate/diploma which should be given by an officially recognised body; this body will have to approve the course and arrange for the necessary examinations. After consultation with representatives of the Scottish Education Department we consider that an appropriate way of achieving this end would be to use the machinery already existing of the Scottish Association for National Certificates and Diplomas. The certificate/diploma should cover both academic and practical content.

Existing Limb Fitters

120 We recognise the value and high standard of the service provided by the limb fitters in post and the need for their satisfactory assimilation into the hospital service. We must, however, leave the detailed arrangements for achieving this with the Scottish Home and Health Department.

121 Should it be decided that as part of the assimilation arrangements it will be necessary to have information on the standard of work performance of the individual limb fitters we suggest that this might take the form of:

(*a*) *either*

particulars of not less than four of their past cases—these, for example, for lower limb fitters could be cases of above knee, through knee, PTB below knee and Syme's amputations. (A similar range would apply for upper limb fitters.)

or

completion of a designated assignment of prosthetic fitting at not less than two specified levels.

and (*b*) letters of recommendation from the consultant in charge of the limb-fitting centre where the candidate is in practice, and from his employer.

Registration of Prosthetists

122 We think that in the long term a registration authority for prosthetists, which would maintain standards within the profession, might be an advantage; the British Orthopaedic Association and possibly the International Committee on Prosthetics and Orthotics might be invited to be associated with it. The question would, however, be one to be pursued by prosthetists themselves, when they have achieved professional status.

Training of Prosthetic Technicians

123 To enable prosthetic technicians to carry out the duties which we consider appropriate and which we have set out in Appendix J, they must have properly organised training. This should take the form of a three-year apprenticeship training scheme, and we have suggested a curriculum in Appendix L, along with the entrance qualifications which should be required.

124 Technician trainees with initiative who have demonstrated the necessary qualities in their contact with the clinical scene should be encouraged by attendance at further education classes to qualify for entry to the prosthetist training programme. In these cases they might obtain exemption from certain elements of that programme.

Chapter 9 Training in Prosthetics for Medical Staff

Training of Prosthetic Surgeons

125 No formal training of medical staff for the artificial limb service has been established, and no degrees, diplomas, or certificates are available in Great Britain as evidence of proficiency. When limb-fitting was the responsibility of the Ministry of Pensions, training was 'in-service' and a surgical, orthopaedic or physical medicine background was looked for in those who would be trained. Since the service has become part of the National Health Service in Scotland the same system of training has continued but because of the association of the limb-fitting service with the orthopaedic service the tendency, which we expect will continue, has been for the recruits to have specialised in orthopaedics.

126 Training is as important for the prosthetic surgeon as it is for the prosthetist, but because he will already have qualified as a surgeon only a limited formal course of instruction is required, lasting in all some eight weeks. As we indicated in paragraph 74 the subjects for which he requires special knowledge and experience, and therefore special training, are amputation surgery, biomechanics and prosthetics. Providing courses in these fields should be a function of the Course Centre to which we refer in paragraph 112 but initially at any rate the surgeons could participate in appropriate parts of the proposed courses for trainee prosthetists.

127 This formal training should be supplemented by a period of in-service training, the trainee visiting different Scottish limb-fitting centres to take advantage of the experience in different aspects of the service which they have developed. We hope also that there will continue to be a close link with centres south of the Border for training purposes as there has been in the past.

128 Practising prosthetic surgeons require to be kept up to date with new developments by attendance at periodic refresher or extension courses. The type of seminar run in recent years at Dundee and attended by representatives from all over the world seems to us ideally suited for this purpose since as well as the opportunity to learn of new developments it allows of informal discussion and interchange of ideas with a wide range of people.

129 Prosthetic specialists from abroad visiting this country have also in recent years given lectures or courses on their particular subjects for prosthetic surgeons and others, and we consider that arrangements of this kind could with advantage be formalised in future under the aegis of the Course Centre.

Training of Orthopaedic Registrars

130 We understand that the Specialist Advisory Committee on Orthopaedic Training of the Royal Surgical Colleges have recommended that programmes of orthopaedic training should in future include experience in prosthetics. During this time trainees will not be able to make any significant contribution to the artificial limb service—their instruction will indeed be an additional commitment for those practising in the service—but the period will give them an insight into prosthetics and be a useful introduction if, later, they decide to practise in this field.

Training of other Surgeons and Registrars

131 Developments in prosthetic techniques constantly open up possibilities for improvements in amputation techniques and it is therefore necessary that any surgeons performing amputations should be aware of them. Courses of the type suitable for prosthetic surgeons will probably be concerned too much with the details of limb-fitting to be of interest to other surgeons, and so courses of a different type will be required for them. These courses should be designed to acquaint those attending with the general principles of limb-fitting, and to concentrate on amputation techniques.

132 We have already suggested in Chapter 4 that before an amputation is performed there should be consultation between the surgeons concerned. The need for consultation has to be made known to surgeons likely to carry out amputations and we recommend that opportunities to do this should be sought through suitable multi-disciplinary meetings and seminars.

Chapter **10** Prosthetic Research and Development

133 Limb-fitting is the culmination of the efforts of many different disciplines, and it is therefore difficult to outline, or predict with any degree of completeness, the areas of scientific research which will lead to improvements in the end result, the rehabilitation of the patient.

134 The need for prosthetic research usually first becomes evident at the clinical level when a problem is encountered in the treatment of amputees. Research is then directed initially to identifying the particular aspect or aspects which need further study and investigation before the specific patient problem can be considered and appropriate devices developed.

Facilities and Staff for Research and Development

135 In the prosthetic context there are normally three stages in any research and development project, apart from any commercial development which may ensue:

(*a*) the basic laboratory research;

(*b*) the trial of prototype devices with selected patients; and

(*c*) the wider clinical trials of an experimentally proven device before it becomes a standard production item; at this stage guidance and constructive criticism (objective and subjective) of clinicians and patients is essential for effective evaluation.

Close clinical associations are obviously important through all stages and we are convinced that research is most effective when the necessary clinical guidance and backing is readily and continually available to the researchers. For this reason we have recommended in paragraph 65 that limb-fitting centres should have space and facilities for research and development work. If commercial production is likely to result, there is obviously advantage in having consultation also at an early stage with industry; Government Departments acting as Production Authorities and other agencies will also have to be consulted.

136 While we have indicated that many different disciplines are involved in research and development, the bulk of the work is in practice done by those trained in engineering, production engineering, bio-engineering and medical physics. The necessary expertise can be made available to the limb-fitting centres by (1) the employment on the staff of the centre of graduates or those with equivalent qualifications in these fields, (2) a link with other National Health Service establishments where such individuals are employed and which have resources for prosthetic research, and (3) recognised association with established University and other organisations engaged in this work. These specialists would be available for consultation by prosthetic surgeons on problems concerning patients, and would become members of the clinic team in appropriate circumstances. They would also advise on and participate in the relevant training and education programmes in addition to their research work.

137 In prosthetic research a substantial service commitment generally has to be assumed by the research team in fitting any devices under development to patients. This commitment has to be borne in mind when the cost of a project, in terms of both time and money, is being assessed.

Areas of Research and Development

138 Appendix M lists the prosthetic research projects at present being undertaken in Scotland. We describe in the following paragraphs two specific areas in which we consider further research and development is urgently needed.

Relation between Amputation Techniques and Limb-making Techniques

139 Research activity should always be viewed against the background of the rehabilitation process of which amputation and limb provision are two of the inter-acting components. Changes and innovations in either one of these necessarily influence the other, but the extent of research effort directed to establishing the nature of their interdependence is at present inadequate. We therefore recommend that there should be intensification of studies on (*a*) the appropriate amputation 'design' to produce the desirable stump characteristics, (*b*) the objective assessment of functional capability remaining after amputation, and (*c*) the matching of the patient to his prosthesis to take full advantage of his residual capability.

Evaluation

140 There can be no doubt of the importance of the artificial limb service in rehabilitating amputees, and in this report we have mentioned many improvements which we think should be made in it. But we consider that there should be further investigation to discover if the best possible value is being obtained in terms of patient satisfaction and the money expended; whether, for instance, the limbs supplied are more sophisticated than some elderly patients are willing or able to learn to use, or whether the needs which some of the appliances supplied for arm amputees are designed to meet could be better met in other ways (*see* paragraph 48).

141 We therefore recommend that an evaluation unit should be set up to assess whether the existing prosthetic devices meet the needs of patients —and do so economically—taking into account the patients' use of the devices and their unsatisfied needs and demands. To do this effectively the unit will have first to establish the precise physical and psychological needs of amputees, including their need for acceptable appearance, their task rearrangements on disablement, and their motivation towards rehabilitation. The unit must then follow up by suggesting the areas in which further scientific research is necessary to enable the patients' needs to be met better, consistent with economy.

142 Such a unit will require a psychologist and, ideally, an ergonomist, as well as the necessary bio-engineering staff. It is not novel in concept as units of this kind exist elsewhere, notably in Sweden. Much can be learned from the work of these other units but none of them operate in conditions which are quite the same as in this country where, in particular, the benefits of the artificial limb service are free and available to all. Although we are, as a Working Party, concerned only to recommend the application of such evaluation to prosthetics, a unit of this type could well extend its activities to the evaluation of orthopaedic appliances, wheelchairs and vehicles for the disabled, and indeed any appliances (in the widest sense of the word) for the physically handicapped.

143 The unit's work could also extend to drafting recommendations for standards and specifications for appliances and to serving as approval authority for new devices developed. This latter function, by providing official recognition of manufacturer's products which are considered satisfactory, could help exports.

Planning and Co-ordination of Research and Development

144 We have noted the closeness of contact and collaboration that exists between various research and development groups in Scotland. We feel that to further and enhance this coherence the establishment of a flexible but possibly more formal organisation might be considered. This could take the form of a Committee for Prosthetic Research and Development based on the Scottish Home and Health Department and charged with the arrangement from time to time of 'workshop' meetings to consider selected aspects of importance and priority in the prosthetic field. The activity visualised is of the kind carried on by the CPRD (Committee for Prosthetic Research and Development)—National Academy of Sciences in USA where a nucleus of permanent members are reinforced by invited experts corresponding to the topic under discussion. It is not intended that such a Committee should direct research or alternatively seek to inhibit it but rather to expedite it in relation to the needs of the artificial limb service. It would maintain a watching brief on research throughout the world, establish guide lines for the future, ensure collaboration and through its working panels produce reports.

Chapter **11** Linking of Prosthetic and Orthotic Services

145 The orthotic service, *ie* the service for the provision of orthopaedic appliances, does not come within our terms of reference but during our deliberations the possible advantages that might accrue from linking the prosthetic and orthotic services have come to our notice. We understand also that there is dissatisfaction amongst orthopaedic surgeons with the present orthopaedic appliance service.

146 During the visit to Scandinavia in March 1969 we had the opportunity of examining in detail a hospital-based service which combined prosthetics and orthotics, and believe that there are cogent reasons for this combination. In the centres we visited men were trained to be prosthetist/orthotists and, although some eventually concentrated on either prosthetics or orthotics, many—especially those at the peripheral centres—continued to practise in both.

147 The advantages of this arrangement are:

(*a*) Prosthetists and orthotists require a similar education in the life and physical sciences, biomechanics and basic workshop training. The tendency in both these professions is towards modular assembly and a gradual introduction of plastics and other new materials.

(*b*) A common core training programme could be provided which would be more viable than one designed for prosthetists alone, as the numbers required to replace vacancies by retirement and expansion in the prosthetic service are small.

(*c*) In this country few orthotists receive any formal training. A course similar to that which we have proposed for prosthetists could result in a marked improvement in the status of orthotists, the quality of appliances they produce, and the service they give to the public.

(*d*) There may be advantages in establishing workshops at some of the district hospitals with orthopaedic departments. These workshops could undertake minor repairs to artificial limbs and the amputee who lived at some distance from his limb-fitting centre would be spared a long journey, and possibly an overnight stay in hospital.

148 We therefore recommend that a common core training for prosthetists and orthotists should be considered and that the possibility of linking the supply, fabrication and repair of orthopaedic appliances with the supply, fabrication and repair of artificial limbs in National Health Service workshops should be examined. We have indeed already passed these views to the Scottish Home and Health Department; they have as a result arranged for a survey of the orthotic service to be carried out so that our suggestion can be considered against an appropriate background of knowledge.

Chapter **12** Transitional Arrangements

149 The recommendations we have made are far-reaching, and we are well aware that their implementation may not be easy. But we are convinced that the difficulties of making the transition will be justified in the long term by the improvement in the efficiency of the service.

150 The implementation of some recommendations is dependent on other changes being possible; the changeover to local fabrication of all limbs, for instance, will be simpler if limbs are made on a modular basis.

151 Changes cannot moreover take place overnight. For example, even when modular limbs are generally available, all patients cannot be supplied with them immediately; conventional limbs being worn by established amputees will have to continue to be repaired and maintained for some time to come. An increase in the number of prosthetists is highly unlikely until new staff have completed the course of training which we recommend, which takes four years. And it will take time to provide the additional accommodation and facilities required at the existing limb-fitting centres or to build new centres.

152 The recommendation that prosthetists be employed by the National Health Service is, however, one which we should like to see implemented quickly. This step will enable prosthetists to take their rightful place alongside surgeons, physiotherapists and others as members of the clinic team, and will permit a career structure for them to be set out. This in turn will enable the possibilities of a career in prosthetics to be demonstrated to potential recruits, and so encourage them to enter training.

Chapter 13 Summary of Conclusions and Main Recommendations

153 In this report our aim has been to recommend ways for improving the service so that its purpose—to restore function as completely as possible to people who have had limbs amputated so that they can lead as full a life as age and other conditions permit—can be more effectively achieved. To this end we consider it to be of prime importance

(*a*) that those concerned with the treatment of amputees, from amputation to re-training for employment when necessary, should work together as a clinic team, each being of professional status and playing his part in the patient's rehabilitation (*paragraphs* 40 and 73):

(*b*) that, consequently, prosthetists should have professional status and be given the necessary training to enable them to attain this, and that they and the prosthetic technicians working at the limb-fitting centres should be employed by the National Health Service (*paragraphs* 81, 94–100 and 101):

(*c*) that the number of medical staff engaged in prosthetics should be increased to allow more time to be devoted to each patient than at present, and in particular to allow each stage of fitting to be supervised (*paragraphs* 79 and 80): and

(*d*) that artificial limbs should in future be designed on modular principles and assembled in local workshops at the centre where the amputee is a patient; a modular system will allow amputees to try out different devices to be incorporated in their artificial limbs until the most suitable is found, and will also facilitate quick repair of limbs by enabling parts to be readily replaced (*paragraphs* 42–46).

154 There are, however, many other improvements in the service which we think are required. We summarise our recommendations for these as follows:

PATIENTS

Pre- and post-operative care of amputees

Patients should ideally be transferred to the charge of the prosthetic surgeon before amputation and have the operation carried out by him; in any event the surgeons concerned should confer before the operation (*paragraphs* 34 and 35).

Rehabilitation of amputees

The proper fitting and quick delivery of artificial limbs is of paramount importance to the satisfactory rehabilitation of amputees (*paragraph* 41).

Patients need thorough training appropriate to their needs in using their artificial limbs, and facilities for this should be provided at centres. Rehabilitation should include training for new jobs where necessary (*paragraphs* 48–50).

MODULAR LIMBS

Interchangeability of components

Arrangements should be initiated to try to secure international agreement on levels of static and dynamic performance and on the standardisation of dimensions (*paragraph* 47).

LIMB-FITTING CENTRES

Location

There should be one limb-fitting centre per Hospital Board Region in Scotland with perhaps a second in the Western Region (*paragraphs* 52–54).

A limb-fitting centre should ideally be part of a general hospital (*paragraph* 56).

Facilities

All limb-fitting centres should have beds associated with them (*paragraphs* 38 and 62).

Limb-fitting centres require consulting and fitting accommodation with special dimensions (*paragraphs* 58 and 60), properly equipped workshops (*paragraph* 59), full facilities for rehabilitative treatment (*paragraph* 61), access to a conference/lecture room (*paragraph* 64), and space for research and development (*paragraph* 65), in addition to the usual facilities of an out-patient department.

Transport

The possibility of using mini-buses to transport amputees should be considered (*paragraph* 68).

Administration

A well-run appointments system is important for patients and staff; this will be easier to arrange if centres have control of limb making and patient transport is properly organised (*paragraphs* 67 and 69).

The record-keeping system should be revised so that reliable statistics are available in future (*paragraph* 71).

STAFFING

Medical Staff

The person in overall charge of the limb-fitting centre and the leaders of the clinic teams should be consultants with special knowledge and experience of amputation surgery, biomechanics and prosthetics (*paragraph* 74).

There should be consultant cover at centres for all clinics, which may entail the appointment of additional consultants, drawn perhaps from different orthopaedic units in the area (*paragraph* 75).

The consultants should have adequate supporting medical staff to exercise the day-to-day care of in-patients and to assist with clinics (*paragraphs* 77 and 78).

Prosthetic Staff

The total number of prosthetists required for Scotland as a whole is about 40 (*paragraph* 82).

Prosthetists should be supported by an adequate number of properly trained prosthetic technicians (*paragraphs* 83–85).

Other Staff

The services are also required of physiotherapists (*paragraph* 86), occupational therapists (*paragraph* 87), medical social workers (*paragraph* 88), nursing staff (*paragraph* 89), administrative and clerical staff (*paragraph* 91), secretaries (*paragraph* 92), and porters (*paragraph* 93).

TRAINING

Prosthetic Staff

The training course for prosthetists should cover basic sciences, clinically orientated applied sciences, advanced studies related to prosthetic function, and liberal studies. The academic content of the course should be presented in an integrated way, and instructional courses should be supplemented by seminars and by practical laboratory and clinical work. Trainees should be introduced to the clinical scene from the beginning of their training (*paragraphs* 103–106).

Recruitment will need to be at the rate of six trainees per year for 8–10 years to build up to the total number of prosthetists recommended for Scotland (*paragraph* 109).

The curriculum for the training of prosthetists should be correlated with that for other paramedical professions to enable training facilities to be shared where possible (*paragraph* 110).

A permanent Course Centre should be established where trainees can receive their academic training and where instruction could be given initially by staff already concerned with the prosthetic service. For practical training trainees should be sent to selected limb-fitting centres (*paragraphs* 112–114).

Prosthetists successfully completing the course should be awarded a certificate/diploma; the machinery of the Scottish Association for National Certificates and Diplomas could be used for this (*paragraph* 119).

Special arrangements should be made for the assimilation of existing limb-fitters into the hospital service (*paragraphs* 120 and 121).

Prosthetic technicians should have organised training in the form of a three-year apprenticeship (*paragraphs* 123 and 124).

Medical Staff

Prosthetic surgeons should have formal courses of instruction supplemented by in-service training in amputation surgery, biomechanics and prosthetics (*paragraphs* 126 and 127).

Refresher and extension courses should be held periodically for practising prosthetic surgeons (*paragraphs* 128 and 129).

All orthopaedic surgeons in training should have experience in prosthetics (*paragraph* 130).

Courses on the latest amputation techniques should be held for other surgeons (*paragraph* 131).

PROSTHETIC RESEARCH AND DEVELOPMENT

Arrangements for Research

Prosthetic research requires close clinical associations (*paragraph* 135).

Limb-fitting centres should employ or have available to them the services of engineers, production engineers, bio-engineers and medical physicists (*paragraph* 136).

Areas of Research

Further research is required into the interdependence of amputation techniques and limb-fitting techniques (*paragraph* 139).

An evaluation unit should be set up to assess whether the prostheses and other devices supplied to amputees meet patients' needs as well as is technically possible consistent with economy (*paragraphs* 140–143).

Co-ordination of Research

The setting up of a Committee for Prosthetic Research and Development should be considered (*paragraph* 144).

LINKING OF PROSTHETIC AND ORTHOTIC SERVICES

Consideration should be given to setting up a common core training for prosthetists and orthotists and to the possibility of linking the fabrication and repair of orthopaedic appliances and artificial limbs in National Health Service workshops (*paragraphs* 55 and 148).

APPENDICES

Organisations and Individuals who gave Evidence

*Northern Regional Hospital Board
*North-Eastern Regional Hospital Board
*Eastern Regional Hospital Board
*South-Eastern Regional Hospital Board
*Western Regional Hospital Board

*Royal College of Surgeons, Edinburgh
*Royal College of General Practitioners (*Scottish Council*)

*British Medical Association, Scottish Office
*Society of Medical Officers of Health (*Scottish Branch*)

*Mr A. McDougall, FRCS, Glasgow
†Mr A. Morrison, FRCS, Inverness
} *Prosthetic Surgeons*

†Mr A. I. S. Macpherson, FRCS, Edinburgh
†Mr G. E. Mavor, FRCS, Aberdeen
†Mr W. Reid, FRCS, Glasgow
†Mr W. F. Walker, FRCS, Dundee
} *Vascular Surgeons*

*Ministry of Labour (now Department of Employment and Productivity)
*Ministry of Social Security (now Department of Health and Social Security)
†Department of Health and Social Security (formerly Ministry of Health)
*Department of Health and Social Security, Biomechanical Research and Development Unit, Roehampton

†British Limbless Ex-Service Men's Association

†British Surgical Trades Association
†Charles A. Blatchford & Sons Ltd.
†Ideal Limbs Ltd.
†Robert Kellie & Son Ltd.

†Institute of British Surgical Technicians
†Association of Scientific, Technical and Managerial Staffs (Scottish Limb Fitters only)

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* Gave written evidence
† Gave oral evidence

Report by the Management Services (O & M) Scottish Branch of the Civil Service Department on a Study of the Organisation of the Artificial Limb Service in Scotland

B.1 We were asked by the Scottish Home and Health Department to assist the Working Party in its examination of the Artificial Limb Service in Scotland, and, at its request, initiated a number of enquiries over a range of activities. This paper briefly summarises our main conclusions.

B.2 One of the questions facing the Working Party was that of deciding whether the arrangements for the supply and fitting of artificial limbs were the most effective and efficient; a specific question was whether the work currently undertaken by independent contractors should (or could) be more closely integrated with the medical, paramedical and administrative functions within the organisational structure of the National Health Service. We did not see it as our function to evaluate the case for closer integration; primary questions of medical and administrative policy and practice weigh heavily in the making of such a decision. But we did try to establish the degree to which practical limitations of organising and carrying out the work should be taken into account.

B.3 We found no major practical difficulty in the way of integrating the limb-fitting function within the Health Service. The technical and organisational role of the limb-fitter would, of course, require re-definition were he a member of the Health Service staff, and formal conditions of service would require to be worked out; but subject to this, we saw no reason to suppose that a change of employer would of itself, adversely affect either the quality of the limb-fitters' work, or the standard of service provided to patients. On the contrary, we see the distinct possibility that integration within the Health Service would enable the limb-fitters to play a fuller part in the development of the team concept approach to the problems of the patient.

B.4 Were the limb-fitting function to become a direct Health Service responsibility, we have little doubt that the work of the benchworkers (and the equivalent work, if and when modular assembly of the limbs assumes practical proportions) should also be undertaken within the Service. We do not think it would be enough for the limb-fitter merely to specify the type and quality of a limb and the time by which it is required; he should be able to take positive steps to control the production/assembly processes, and to vary them to meet patient needs. His responsibility for the supply of limbs requires that he should have the authority commensurate with it, and we think that he would be able to achieve his purpose satisfactorily only if he were able to control (directly, or through an intermediary in the same organisation) the work of producing and assembling limb components.

B.5 The work of making, assembling and repairing limbs is shared between contractors' staff attached to Limb Centres and others employed in larger factories. The precise arrangements for sharing the work-load vary as between contractors, but the factory is not only a centre of specialised work where special skills and equipment are available; it also provides a means of stabilising work-loads in the Centres, by taking work from, and shedding it to, individual Centres as their work-loads vary. A similar facility to cope with peaks and troughs of work would have to be provided within the Health Service, were the work to be undertaken directly; this is one area where we have suggested to the Department that a more extensive study of the problem is required. Nevertheless we are satisfied that a practical arrangement can be worked out.

B.6 We also see the need to make more detailed studies of (*a*) the processes, production methods and control arrangements for making limbs (particularly if modular limbs are likely to be on issue within the near future); (*b*) the store-keeping and stock control arrangements; and (*c*) the supporting administrative procedures. We have instanced these and other related areas of enquiry to the Working Party and the Department. Many problems remain to be tackled in detail before definite organisation and staffing proposals can be made; but in no area that we subjected to examination did we detect foreseeable practical difficulties which stand in the way of a decision in principle to integrate the artificial limb supply and fitting functions into the organisational structure of the National Health Service.

Report on Visits to Prosthetic Centres in Denmark and Sweden

C.1 In March 1969 a group of us, comprising the Chairman, Professor Barnes, Mr Gardner, Mr Murdoch, Mr Whitefield and the lay Secretary, along with the O & M Officer who carried out the survey for us at one of the Scottish limb-fitting centres, visited prosthetic centres in Denmark and Sweden. An independent visit was later made by Mr Lamb and Dr Simpson.

C.2 Before the visit we had reached the tentative conclusion that artificial limbs should be fabricated in local workshops, and that the prosthetists and prosthetic technicians should be National Health Service employees like the surgeons and others concerned with the treatment of amputees. Before making firm recommendations on these points, the implementation of which would involve radical changes in the existing arrangements, we felt it advisable that we should study at first-hand a service which was already operating on the lines we envisaged. The prosthetic services in Scandinavia are regarded, internationally, as being of a very high standard and we therefore arranged to visit a centre at the Orthopaedic Hospital in Copenhagen where artificial limbs are made on the premises by staff employed by the hospital, and also a centre at Uppsala where the limbs are made on the premises but the staff doing so are employees of a commercial firm. Denmark and Sweden also have populations numerically of the same order as that of Scotland, so that we felt that comparisons would be valid.

C.3 We also when in Sweden had discussions with representatives of the Swedish Institute for the Handicapped in Stockholm on the prosthetic research work being done there including the work of the assessment unit which evaluates technical aids for the handicapped.

C.4 Our visits confirmed our tentative views on the future of the artificial limb service in Scotland. Although the excellent service in Uppsala was provided by a commercial firm we felt that the circumstances there were very particular to that centre and that this was not a pattern which could be relied on for general application: the adoption of the Danish system where fitters, workshop staff, medical staff and other members of the clinic team are all hospital employees seemed to us more likely to be successful.

C.5 The following were points we particularly noted on our visits:

(*a*) *Clinic Team Approach*
The outstanding impression of the visits was the way in which the various people concerned with looking after amputees in both Copenhagen and Uppsala worked together as a closely integrated team; while the surgeon was acknowledged as the leader the other members of the team were each of professional

status and contributed to the treatment of the patient according to their particular skill and training. Siting of centres, including the workshops where limbs were made, in a hospital environment undoubtedly facilitated and encouraged this type of approach, although in neither Copenhagen nor Uppsala did the staff consider the physical conditions to be ideal. In Copenhagen, however, a new limb-fitting centre associated with a large general hospital and a training school was being set up.

(*b*) *Work-load and Fitting Times*

In Copenhagen the clinic team, comprising surgeon, prosthetist, physiotherapist and social worker, saw an average of 15 patients in a three-hour session; the number would include 3 or perhaps 4 primary amputees. The time taken by a prosthetist in fitting a limb, including cast rectification, was estimated to be 2½ to 2¾ hours for a patellar tendon bearing below-knee limb and 4 hours for an above-knee limb. A primary amputee would have this period of time devoted to him twice or thrice in the first year after amputation, as during this period he would require two or three sockets.

Comparable figures of clinic load were not available for Uppsala but fitting times were similar to those quoted for Copenhagen.

(*c*) *Local Fabrication of Limbs*

The advantages of having artificial limbs made on the premises where patients were being treated and rehabilitated were amply demonstrated, *ie* that the fit of the limbs was better and that delivery times could be arranged according to patients' needs. Component parts for limbs were bought in from any source from which they were available; many parts were in fact obtained, particularly in Sweden, from Otto Bock, Hosmer and other firms abroad.

(*d*) *Delivery Times*

Using quick-setting resins for sockets the Swedes were able to give same-day delivery for definitive limbs when required; the normal delivery times ranged from 3 to 4 weeks.

In Denmark production of non-urgent limbs sometimes took as long as 5 to 6 weeks but this was a deliberate policy to even out production in the workshops and enable quick delivery to be effected where this was needed.

(*e*) *Quality of Artificial Limbs Supplied*

In both countries the quality of the limbs supplied, in terms of fit, appeared to be higher than in Scotland. In Denmark, where most limbs are still made of wood (with plastic sockets), fit had to be good to compensate for the additional weight, and in Sweden adjustments, apart from those necessitated by stump changes, were done free as part of the price of the limb so that the contractor had an incentive to fit well in the first instance.

(*f*) *Orthotics*

Prosthetics and orthotics are regarded as one discipline in Scandinavia. This seemed to us to offer considerable advantages: not only was staff training more easily organised because of the larger numbers but a greater decentralisation of the combined service was possible. The orthotic service is outside our remit but we felt that the possibility of a closer link between it and the prosthetic service in Scotland might well be considered.

(*g*) *Prosthetists*

Prosthetists (and orthotists) in both Denmark and Sweden at present receive their initial training as craftsmen (4 years in Denmark and 3 years in Sweden), and after spending a year as qualified craftsmen, train for 2½ years (including academic training by correspondence or otherwise) to become prosthetist/orthotists; after passing specific tests or examinations they are then certified as prosthetist/orthotists.

This type of training is considered in both countries now to be outmoded and a change is to be made to a four-year course, including one year's clinical attachment, and orientated from the beginning to prosthetist/orthotist, which recruits would enter at age 16 to 17 after taking the equivalent of O levels. A proposal is being considered that a central prosthetic school for the whole of Scandinavia should be set up in Denmark, where medical staff and technicians as well as prosthetist/orthotists could receive training.

From a comparison between their salary scales and those of medical and other paramedical workers the status of the average prosthetist/orthotist appears to be half way between the other two, so that they would in this country rank at ordinary graduate level.

(*h*) *Surgeons*

No one in the medical field in Scandinavia works full-time on prosthetics. In Uppsala orthopaedic surgeons work on a sessional basis, and while in training spend three days per week in a prosthetic unit for a spell of six months. A similar arrangement applies in Copenhagen.

(*i*) *Rehabilitation*

Physiotherapy in both Denmark and Sweden is of a very high standard. The ratios of staff to patients is higher than in this country although the Danes and Swedes consider that it is not high enough.

The facilities for physiotherapy which we saw were also good in terms of space and equipment. The value of a good swimming pool was manifest.

The re-training of arm amputees was carried out by occupational therapists.

(*j*) *Research*

An elaborate programme of research is now under way in Sweden but at the time of our visit it had not produced any hardware. The most interesting feature was the assessment unit set up to evaluate technical aids for the handicapped including artificial limbs; in this unit psychologists were working in collaboration with engineers. We felt that this was a type of unit badly needed in this country.

The principal item of prosthetic research and development demonstrated in Denmark was a new type of prosthesis for through-knee amputees. (Following the visit arrangements have been made to collaborate with the Danes in the further development of this prosthesis.)

(*k*) *Location of Centres*

There are 9 prosthetic/orthotic centres in Denmark, which has a population of 3½ million. In Uppsala the opinion was expressed that the optimum population for a centre to serve was one million. In both countries the view was firmly held that centres should be based at major hospitals.

(*l*) *Transport and Accommodation of Patients*

In Denmark a special minibus service was operated for patients who were able to travel to the centre for fitting and rehabilitation. Patients who could not travel lived in a hostel associated with the centre if they were able to look after themselves; otherwise they were accommodated in the hospital as in-patients.

In Sweden also, self-care accommodation and hospital accommodation were available as necessary.

Patient Statistics

D.1 The form AP1 was introduced in the 1920s as a record of amputations and prostheses supplied. It was revised with the agreement of all the orthopaedic surgeons attached to limb-fitting centres in Scotland in 1965, and arrangements were made for its completion at limb-fitting centres and transmission to the Research and Intelligence Unit of the Scottish Home and Health Department for coding and processing. The form comprises three parts:

Part I—Patient's Details
Part II—Particulars of Surgical Amputation
Part III—Limb-fitting and Training

and was designed to provide a longitudinal study of amputees, terminating in date and cause of death. The forms were to be transmitted between limb-fitting centres and the Research and Intelligence Unit as additional information came to hand. 75 columns were available for recording this data on punch cards. It was hoped thus to obtain valuable statistical information which would facilitate both clinical and operational research on the artificial limb service in Scotland.

D.2 Had a form AP1 been fully completed in respect of each new patient attending a limb-fitting centre and the data processed we should have had at our disposal a comprehensive picture of the work being done at limb-fitting centres. This proved not to be the case.

D.3 Enquiries were therefore made of each centre to discover the number of new patients attending over the past 5 years and the number of patients on the amputee register during the same period, distinguishing between upper and lower limb cases. The figures we obtained are shown in the attached tables, but further investigations have shown that the numbers of new patients are likely to be underestimated while the numbers of patients on the register are overestimated.

D.4 As it was considered that there might possibly be an unmet need for limb-fitting, the Research and Intelligence Unit were asked to supply a record of all amputations performed in 1966 from their hospital in-patient records. The names of the patients thus traced were sent to the limb-fitting centres to establish whether the patients had attended for fitting. A considerable number of patients undergoing amputation are elderly and suffering from other diseases; some of these patients die in hospital while others may succumb before they can be referred to a limb-fitting centre. Nevertheless, it proved possible to trace the majority of the amputees and there was no evidence that any appreciable number of patients who had amputations and were suitable for limb-fitting were not being referred to the limb-fitting centres. A number of surgeons who were members of the Working Party also made individual studies of operations registers in their own hospitals which confirmed this finding.

NUMBERS OF NEW PATIENTS

(*See, however, paragraph D.3 above*)

		Limb-fitting Centres				Whole of Scotland
		Glasgow (including Victoria)	Edinburgh	Dundee	Aberdeen* (including Inverness)	
1965	Arms:	29	11	1	7	48
	Legs:	230	101	48	51	430
1966	Arms:	38	26	7	9	80
	Legs:	270	84	57	64	475
1967	Arms:	35	24	2	6	67
	Legs:	273	134	50	83	540
1968	Arms:	28	13	2	7	50
	Legs:	230	116	49	61	456
1969	Arms:	33	28	1	5	67
	Legs:	240	150	45	66	501

* The figures for Inverness are included in the Aberdeen figures

NUMBER OF PATIENTS ON AMPUTEE REGISTERS OF LIMB-FITTING CENTRES

(See, however, paragraph D.3 above)

	AT 31 DECEMBER 1966					
	ADULTS				CHILDREN	
	Male		Female		Male	Female
	W.P.	NHS	W.P.	NHS	NHS	NHS
ARMS						
Aberdeen*	101	126	1	43	8	6
Dundee	35	92		49	6	5
Edinburgh	169	228		55	25	40
Glasgow (Belvidere)	309	648	1	238	45	38
TOTAL	614	1094	2	385	84	89
LEGS						
Aberdeen*	285	397	3	185	5	6
Dundee	184	689		233	5	5
Edinburgh	432	839		377	27	17
Glasgow (Belvidere)	721	1993		734	62	25
Glasgow (Victoria)	183	258		88	7	4
TOTAL	1805	4176	3	1617	106	57

Arm amputees	NHS Adults	1479	Leg amputees	NHS Adults	5793
	WP Adults	616		WP Adults	1808
	Children	173		Children	163
Total arm amputees		2268	Total leg amputees		7764

* The figures for Inverness are included in the Aberdeen figures

	AT 31 DECEMBER 1967					
	ADULTS				CHILDREN	
	Male		Female		Male	Female
	W.P.	NHS	W.P.	NHS	NHS	NHS
ARMS						
Aberdeen*	100	125	1	43	7	6
Dundee	31	87		50	6	5
Edinburgh	161	228		56	29	43
Glasgow (Belvidere)	305	666	1	241	49	42
TOTAL	597	1106	2	390	91	96
LEGS						
Aberdeen*	284	405	3	191	6	7
Dundee	174	694		236	5	5
Edinburgh	422	853	1	393	31	17
Glasgow (Belvidere)	680	2034	1	747	46	28
Glasgow (Victoria)	181	265		100	9	2
TOTAL	1741	4251	5	1667	97	59

Arm amputees	NHS Adults	1496	Leg amputees	NHS Adults	5918
	WP Adults	599		WP Adults	1746
	Children	187		Children	156
Total arm amputees		2282	Total leg amputees		7820

* The figures for Inverness are included in the Aberdeen figures

AT 31 DECEMBER 1968

	ADULTS				CHILDREN	
	Male		Female		Male	Female
	W.P.	NHS	W.P.	NHS	NHS	NHS
ARMS						
Aberdeen*	99	127	1	44	7	7
Dundee	33	84		46	6	5
Edinburgh	161	228		56	30	44
Glasgow (Belvidere)	300	673		252	51	43
TOTAL	593	1112	1	398	94	99
LEGS						
Aberdeen*	275	424	3	208	6	10
Dundee	169	680		230	5	5
Edinburgh	422	886		418	33	19
Glasgow (Belvidere)	651	2060		777	70	30
Glasgow (Victoria)	174	302	1	133	10	4
TOTAL	1691	4352	4	1766	124	68

Arm amputees	NHS Adults	1510	Leg amputees	NHS Adults	6118
	WP Adults	594		WP Adults	1695
	Children	193		Children	192
Total arm amputees		2297	Total leg amputees		8005

* The figures for Inverness are included in the Aberdeen figures

	AT 31 DECEMBER 1969					
	ADULTS				CHILDREN	
	Male		Female		Male	Female
	W.P.	NHS	W.P.	NHS	NHS	NHS
ARMS						
Aberdeen*	98	130	1	44	6	8
Dundee	32	82		46	6	5
Edinburgh	164	238		63	35	49
Glasgow (Belvidere)	291	672		258	52	44
TOTAL	585	1122	1	411	99	106
LEGS						
Aberdeen*	288	443	3	195	8	8
Dundee	158	703		247	5	6
Edinburgh	412	906	1	426	34	20
Glasgow (Belvidere)	618	2026	2	761	71	30
Glasgow (Victoria)	170	304	1	136	10	5
TOTAL	1646	4382	7	1765	128	69

Arm amputees	NHS Adults	1533	Leg amputees	NHS Adults	6147
	WP Adults	586		WP Adults	1653
	Children	205		Children	197
Total arm amputees		2324	Total leg amputees		7997

* The figures for Inverness are included in the Aberdeen figures

Modular Assembly Prostheses

General

E.1 Modular assembly is the name given to systems in which prostheses are assembled from pre-manufactured standardised components. Modules within a given system are interchangeable and the adoption of modular assembly systems internationally will provide the opportunity of interchanging devices and components of different systems. Modular assembly systems are a logical development in the modern approach to patient treatment.

E.2 There are several modular assembly systems already in existence and others at various stages of development throughout the world. At present, however, the majority of prostheses are constructed in a traditional manner using traditional materials. In the United Kingdom the principal material used is sheet metal although wood is widely used elsewhere; but plastics are coming increasingly into use. There are disadvantages inherent in traditional methods of construction—particularly in relation to production efficiency and patient care. By the nature of the construction there are limitations to the degree of standardisation possible and in consequence each prosthesis requires many hours of hand work by skilled craftsmen. This in turn leads to manufacturing periods which are normally measured in weeks and often in months. While satisfactory fittings can be and are produced, the inflexibility of the design and materials—particularly in the case of metal shell construction—often leads to results which are less than optimal.

Basic Features

E.3 The basic requirement is for a system which will provide a rapid means of supply to the patient. The system should make the maximum use of modern production techniques and the prosthesis supplied should best fit the needs of the individual patient. The modular system meets these requirements in the following way:

E.4 Assembly is from pre-manufactured standardised components. This means that modules may be produced as efficiently as any other engineering component. Assembly is rapid and in terms of patient care, the critical factor in determining the time taken to produce a definitive prosthesis becomes the manufacture of the socket. As a result equipping a patient in a matter of hours becomes a real possibility. The importance of this in the rapid rehabilitation of all grades of patients needs no emphasis.

E.5 Completed lower limb modular assemblies may incorporate a device or devices to allow the alteration of the physical arrangement of the socket and foot and any intervening joints. The process of arranging these components following observation of the patient walking with the prosthesis is known as dynamic alignment. Devices used to alter dynamic alignment are called alignment units. Such devices must be simple to manipulate to permit the prosthetist readily to achieve the best dynamic alignment for the individual patient. Furthermore, because the alignment unit can be a permanent part of the prosthesis, it becomes possible to alter the alignment during the course of the patient's treatment if this should prove desirable. For example, a primary amputee may require progressively less alignment stability as his confidence and functional capability improves. This has never been practicable with traditional methods where major structural alterations to the limb would be entailed.

E.6 Modules within the system are also interchangeable, providing another facility which can perhaps best be illustrated by consideration of knee mechanisms for the primary amputee. During the course of his treatment he may progress from a requirement for some version of stabilised knee to one embodying a greater degree of voluntary control. With the modular system this may be simply and quickly achieved by exchanging the relevant device modules. A further advantage of the system is that even when as at present objective criteria for prescription are lacking, the 'best' device for a particular patient may nevertheless be subjectively arrived at on a trial basis.

E.7 The components of modular system limbs include sockets, receptacles or bases, alignment units, assistive or control devices, *eg* knee, ankle/foot, elbow etc., connector pieces and cosmetic covers. An above-knee prosthesis, for example, might consist of a socket, an alignment device, a knee piece, shin tube and an ankle/foot module; an above-elbow prosthesis might consist of a socket, an elbow mechanism, a forearm, a rotational device and a terminal attachment. In both cases, the limb would be completed by covering it with a cosmetic fairing.

E.8 A characteristic of the modular system is that its components are not only readily assembled but easily secured and conversely easily disconnected. Thus at any time in order to accommodate replacement of worn parts or changes in prescription, components can be easily removed and replaced. In consequence it may not be necessary to supply duplicate limbs in all cases.

E.9 Sockets for the present must continue to be made individually. The use of improved stump casting techniques and plastic fabrication have simplified the procedure and made possible better results in terms of socket fitting. Trends suggest that in certain cases it may become feasible to replace individual fitting by minor modifications of a suitable socket chosen from a standard pre-manufactured range.

Economic Considerations

E.10 Such systems of modular assembly from standard components are potentially more economic than the 'craft' type method of construction. At this stage, however, it is not possible to claim that a modular limb would at all times be cheaper than the corresponding conventional limb. Against this it is generally accepted that factors such as the supply of standardised components on competitive tender, reconditioning of component parts, together with the total potential volume of production of a given component, will so interplay as to reduce rather than increase the total cost.

The Technique of Immediate Post-operative Fitting of Artificial Limbs

F.1 In immediate post-operative fitting the 'socket' of the temporary limb is applied to the stump at the end of the operation, in the form of a plaster of Paris cast. The socket thus formed has to take account of the forces which will later be imposed upon the stump and thus must embody prosthetic principles. Once the socket is formed a device, known as a disconnect, is attached which permits completion of the limb by the attachment of pylon tubing and artificial foot in the case of a below-knee amputation, with the addition of a knee unit in the case of an above-knee amputation. At varying periods of time, but for many patients within 2–3 days of operation, weight-bearing on this temporary prosthesis is started. Thereafter increasing increments of load and of walking time are added in the process of rehabilitation. The plaster socket is usually replaced once but sometimes more often and a definitive prosthesis can be fitted as early as 28 days post-operatively in the uncomplicated case.

F.2 It is claimed that this process of immediate post-operative fitting has psychological advantages—as well as physical benefits in respect of gait training (neuro-muscular continuity), reduction of oedema, improved wound healing, less pain, etc. It is further claimed that fewer prosthetic changes are required in the first two years following operation with obvious financial advantages. Evaluation of such a technique is extremely complicated as many factors are involved. The main factors are the disease which necessitates the amputation, the surgical technique, the environment placed upon the stump, the timing and proportion of weight bearing permitted and perhaps also the enthusiasm of the workers involved in such a project.

F.3 It can be said that most of the claims have been substantiated in those cases requiring amputation for causes other than peripheral vascular disease. The technique is applicable for upper extremity amputations in almost every case.

F.4 As yet the philosophy has not been proved in cases suffering from peripheral vascular disease although among others, one series in Seattle which proved outstandingly successful has been recorded. Some workers have abandoned the procedure and others have been encouraged to go on. The difficulties which arise in the management of patients with peripheral vascular disease include multiple handicaps and the difficulty in evaluating tissue quality and in deciding upon the level of amputation. Sufficient success has been gained both in the United Kingdom and abroad to suggest that the procedure is of value in cases of peripheral vascular disease provided that due recognition of these factors is made. The condition of the patient may be such that weight-bearing is contra-indicated; associated handicaps may modify the weight-bearing programme, and occasionally the programme itself may have to be abandoned. Even so there is no evidence to show that the more conventional methods of management of the patient are in any way superior to immediate post-operative fitting. With the care and supervision required of any medical procedure certain advantages are clearly demonstrated; the technique permits uninterrupted rehabilitation, stump volume is better controlled and the psychological uplift to the patient is manifest.

Powered Prostheses

G.1 Powered artificial limbs, *ie* limbs operated by, or with the assistance of, some external power source such as gas cylinders or electric batteries, are a comparatively recent innovation and so far have been supplied in Scotland only to children born without arms.

G.2 The children fitted are drawn mainly from the thalidomide group and have handicaps ranging from complete bilateral upper limb amelia to bilateral upper limb phocomelia.* 20 children have been fitted but limbs were withdrawn (1964) from 9 of these when it became clear that their function with their phocomelic limbs was better than any provided by a prosthesis at that time. More than 90 prostheses have been fitted to the group since mid-1963, an average of about 1 per month for seven years.

G.3 The present prosthesis is powered by CO_2 gas obtained from small cylinders and provides a hand-raise/lower movement and a wrist rotation in addition to prehension; both of the first two movements are controlled by a position servo control system which allows unconscious control of the device. Development of a multimovement arm which will give a full range of arm movement is progressing. This will replace the earlier prosthesis.

G.4 The number of children fitted with this powered prosthesis will probably rise to between twenty and thirty as the additional facility of this arm and the changing needs of the children now that they are older will create a demand for it from some of the phocomelic children who previously had better function with their own limbs than could be provided by a prosthesis.

G.5 Initially only one powered prosthesis at a time was supplied to each child but now a duplicate is provided because these children are very handicapped indeed without their prostheses particularly if they also have deformities of their lower limbs and wear calipers.

G.6 The extension of the provision of powered arms to adults, which it has always been hoped would be possible, has now begun. Initially the supply will be of myo-electric hands to appropriate patients but later, when the larger (150 grm.) cylinder is available, gas-powered prostheses constructed from commercially available prosthetic components but controlled by position servo controls will be fitted.

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* Upper limb amelia —complete absence of upper limbs
Upper limb phocomelia—a seal-like flipper hand is suspended directly from the shoulder girdle; the number of fingers is variable but there is usually three or four

G.7 Some research into the feasibility of powered lower limbs has been carried out.

G.8 As a corollary to the development of powered arms, research is also being undertaken to find an alternative source of power to the CO_2 cylinders at present used. The difficulty and the economics of recharging the cylinders contrast unfavourably with those of an electrically based system, but the weight of the actuators in the latter has in the past ruled out electrical systems for a complete arm prosthesis.

APPENDIX H

Medical Time required for the Artificial Limb Service

H.1 A reasonable basis for the calculation of the time required by medical staff for basic prosthetic work would be as follows:

> For each primary amputee in the first year after amputation an average of three and a half hours to allow for prescription and measurement, fitting, and delivery of the first and second limbs, the subsequent review and refitting of these limbs to take account of stump changes, and the supervision of rehabilitative training;
>
> for each primary amputee in the second year after amputation an average of 30 minutes for further review and adjustment of the limbs;
>
> for each child amputee, *ie* amputee under the age of 18 (whether surgical or congenital) an average of three and a half hours per year to allow for review and adjustment or replacement of limbs as the child grows;
>
> for established adult amputees who require replacement of their artificial limbs, an average of 50 minutes; for all other established adult amputees an average of 15 minutes.

H.2 On the present number of amputees the calculation of hours and sessions for Scotland as a whole would therefore be as follows:

	Hours	Sessions
550 primary amputees at 3½ hours	1925	
550 primary amputees at 30 minutes	275	
350 child amputees at 3½ hours	1225	
1000 replacements at 50 minutes	833	
7550 other patients at 15 minutes	1888	
Total	6146	2049

H.3 In assessing the number of staff required for each limb-fitting centre allowance has to be made for holidays, sick leave, attendances at courses, etc. The yearly number of sessions for each centre should therefore be divided by 44 to find the number of medical staff required if each were giving one session per week. This figure will have to be adjusted appropriately to take account of the varying number of sessions per week which each of the medical staff will in fact give.

H.4 These times assume (*a*) that modular limbs which can be assembled quickly at centres from component parts will be available and that the temporary pylon prosthesis at present often supplied in the case of lower limb amputations will not be required, and (*b*) that the medical staff will have the help of prosthetists, trained to the standards we recommend, and other competent ancillary staff. If these conditions do not apply, then more medical time will be required.

H.5 The times quoted moreover refer only to work directly concerned with limb-fitting in an out-patient situation. They do not include time required for the management of in-patients in any residential accommodation associated with the centre, the replacement of plasters for patients undergoing immediate post-operative fitting, surgery, or any pre-amputation consultations which prosthetic surgeons have with other specialists. (Many of these duties are at present carried out by prosthetic surgeons during sessions allocated to general orthopaedic work.) Nor do they include time required for teaching and research or the time needed for general administration. To take account of these additional duties, most of which will by their nature be performed by the consultant in charge, the number of sessions may have to be increased by an amount ranging as high, for some centres, as twenty-five per cent.

Job Description for Prosthetists

I.1 The prosthetist is a member of a clinic team, led by the prosthetic surgeon, which includes, in addition to these two, the physiotherapist, the occupational therapist, the nurse and the medical social worker. As such he should have professional status.

I.2 Because of his special and close relationship with patients, he must be able to establish and maintain rapport, and to inspire confidence in the patient. He should be capable of explaining prosthetic procedures clearly to patients of all ages and levels of intelligence, and of getting them to explain their difficulties to him.

I.3 He must also be able to communicate his ideas orally, in writing, and by demonstration when necessary, with surgeons and other members of the team, with fellow prosthetists, with prosthetic technicians, with administrative staff of hospitals and limb centres, and with research workers and others, some of whom may not be familiar with prosthetic concepts. Communication may have to be to individuals or to groups through lectures and discussions.

I.4 He should be able to keep abreast of new ideas and developments in his field and contribute to them, and he must be capable of supervising the work of other staff, and of managing a small organisation.

I.5 His functions are as follows:

(*a*) *as a member of the clinic team*

(i) to give advice on the selection of a prosthetic device, including the socket, the method of suspension, the method of control, and the selection of the proper components;

(ii) to assist, advise and participate as required in pre-surgical and post-surgical procedures and the necessary prosthetic services;

(iii) to participate directly in the evaluation of the final design including fit, function and cosmesis, *ie* the general quality of appearance of the prosthesis in all its aspects;

(iv) to record and take into account as necessary, any pertinent information regarding patients and their backgrounds.

(*b*) *as prosthetist in contact with the patient*

(i) to make all necessary casts and measurements of patients and record all pertinent information;

(ii) to perform all modifications of positive models, or formulate socket plans and layout;

(iii) to formulate prosthetic design including model and pattern making and the selection of materials;
(iv) to perform fitting and the static and dynamic alignment of devices on patients;
(v) to evaluate the device on the patients and to take any further action necessary to ensure the best fit, function, cosmesis and workmanship.

(*c*) *as manager*

(i) to allocate work to staff and to relate this to the requirements of patient load;
(ii) to supervise the activities of the prosthetic technicians;
(iii) to manage workshop activities assigned to him, including inventory and stock control, use of tools and equipment, industrial safety, and record keeping.

(*d*) *as teacher*

(i) to conduct 'on the job' and apprenticeship training programmes for prosthetist and technician trainee as necessary;
(ii) to devise and conduct re-training programmes as necessary for other prosthetists.

(*e*) *as research and development worker*

(i) to devise improved job methods for increasing efficiency;
(ii) to develop new techniques as necessary to keep pace with new developments;
(iii) to engage in research as circumstances allow, either in collaboration with other research workers or independently.

Any one prosthetist may not cover the full range of functions, but to ensure flexibility within the service and the maintenance of interest he must be trained to undertake them all.

Job Description for Prosthetic Technicians

J.1 The prosthetic technician works at all times under the direction of the prosthetist. He must possess or acquire the necessary skills to enable him to carry out the following duties:

(*a*) Fabrication and assembly of prosthetic devices including component parts, sockets, suspension systems as designed by the prosthetist.

(*b*) Bench alignment of devices to the specifications of the prosthetist.

(*c*) Assisting the prosthetist as directed in fitting and aligning activities with patients.

(*d*) Performing finishing operations on prostheses including the use of alignment transfer tools and equipment.

(*e*) The repair of prostheses as directed by the prosthetist.

(*f*) Reporting any pertinent information regarding devices to the prosthetist.

(*g*) Reporting to the prosthetist any special needs regarding workshop materials, equipment or tools.

(*h*) Responsibility for the care and economy of use of workshop materials, equipment and tools.

(*i*) Suggesting improvements in job methods in workshop.

(*j*) Responsibility for supervision of apprentice technician training under direction of the prosthetist.

J.2 He may eventually specialise in job or process and become a highly skilled craftsman with a particular material or method such as plastic lamination, and should be capable of keeping abreast of new developments in materials, tools, equipment and processes as they apply to his duties in the workshop.

Training Syllabus for Prosthetists

Specimen Course

K.1 The course as outlined is designed for those over 16 years of age who have completed a continuing education up to University entrance level; they need not have obtained the certificates necessary for University entrance but should have the ability necessary to enable them to follow the curriculum of training. It is recognised that this level may be reached along different pathways such as regular school education, apprenticeship training with supplementary academic classes, etc. The latter type of entrant might, for example, come from the ranks of the prosthetic technicians.

K.2 Such a course of education and training will require to be of four years' duration. A student who successfully completes the course will have spent some 30 per cent of his time in academic study and 70 per cent in practical instruction and experience. Each of these aspects would be spread in the proportion stated throughout the four years. The academic study could consist of formal lectures with associated laboratory and clinical studies, while the practical side would cover the necessary spectrum of workshop training, prosthetic practice and clinical experience.

K.3 We consider that the total number of hours per week spent by a student attending the academic part of the programme (lectures, laboratories and clinics) should not exceed 24 hours. During his practical training he should work the normal hours of the practising prosthetist. On the basis of a 48-week year excluding examinations, public holidays, etc., these figures amount to 1920 hours of academic study and 4480 hours of practical training.

K.4 Each year's work is assessed by written examinations and by completion of set practical projects, progress from year to year being conditional on specified levels of attainment being reached. Certification at the conclusion of the course is conditional on the requisite level of proficiency being reached in the work of the fourth year together with satisfactory completion of a major prosthetic project during this period.

Subjects and Time Allocation

Year	*Subject Code*	*Subject*	*Time per Year*
1	101	Life Sciences—Lectures—	
		Bio Science	40 hours
		Applied Human Biology	40 hours
		Laboratory and Tutorial	50 hours
	102	Physical Sciences—Lectures—	
		Applied Mechanics	50 hours
		Properties of Materials	50 hours
		Applied Electricity and Electronics	50 hours
		Technical Mathematics	50 hours
		Laboratory and Tutorial	150 hours
	103	Basic Workshop Training—Woodwork	6 weeks
		Metalwork	6 weeks
	104	Prosthetic Workshop Training	12 weeks
	105	Introduction to Clinical and Prosthetic Practice	4 weeks
2	201	Life Sciences—Lectures—	180 hours
		Laboratory and Tutorial	90 hours
	202	Biomechanics—Lectures—	70 hours
		Laboratory and Tutorial	50 hours
	203	Liberal Studies—Lectures	40 hours
	204	Clinical Studies	50 hours
	205	Clinical and Prosthetic Practice	28 weeks
3	301	Life Sciences—Lectures—	130 hours
		Laboratory and Tutorial	80 hours
	302	Biomechanics—Lectures—	80 hours
		Laboratory and Tutorial	40 hours
	303	Liberal Studies	40 hours
	304	Clinical Studies and Procedures—Lectures and Demonstrations	110 hours
	305	Prosthetic Practice	28 weeks
4	401	Prosthetic Science—Lectures—	150 hours
		Laboratory and Tutorial	90 hours
	402	Clinical Procedures—Lectures and Demonstrations	240 hours
	403	Clinical Practice	4 weeks
	404	Prosthetic Practice	24 weeks

Outline Syllabus of Subjects

Bio Science 101—A course intended to provide students with no previous experience in biology with an introduction on an elementary level to the structure and function of living systems.

The chemical nature and the properties of organic substances—the origins of life, protein synthesis, cell theory—ultrastructure of cellular components chromosomes, cell division and differentiation, tissue organisation—evolution of the primates, reproduction, elementary embryology, human growth and maturation.

Associated laboratory work consisting of practical demonstrations with student participation on selected aspects of human biology.

Applied Human Biology 101—Human constitution, anthropometry, body component characteristics, *eg* centres of mass, inertia, etc.—limb function, locomotion, proprioception, muscle dynamics, electromyography—structure and functional properties of joints—skeletal and connective tissues, their mechanical properties, elements of micro-anatomy—the assessment of human performance, elements of ergonomics, prosthetic concepts. Laboratory experiments designed to introduce students to the practical techniques at present in use in deriving body component characteristics, anthropometric indices; muscle action monitoring, gait analysis.

Applied Mechanics 102—Force analysis: conditions of equilibrium, application to planar and simple space systems. Displacement analysis: time rates of change, equations of motion, application to displacement, velocity and simple acceleration diagrams. Force displacement analysis: applications to direct and shear stress and strain, work power and energy under static and dynamic conditions in solids and fluids.

Properties of Materials 102—Basic metallic materials, alloys, heat treatment, properties and applications—basic non-metallic materials, plastics, fibre reinforced and other composites, properties and applications—corrosion, degradation, fatigue, creep and fracture—tissue compatibility—prosthetic materials and developments.

Applied Electricity and Electronics 102—Electrical Units, circuit elements, principles of amplification, feedback, interference and associated topics. Instrumentation—accuracy: error sources: strain gauges, thermocouples, resistance thermometers, inductance probes, capacitance probes, crystals. Systems—ultrasonics, F.D.M. telemetry, strain gauge bridges, data logging. Principles of electrical safety in hospitals.

Technical Mathematics 102—Calculus: differentiation and integration using graphical and numerical techniques. Algebra: Cartesian and polar co-ordinates; linear, second order and simultaneous equations. Elements of statistics; distributions, sampling, significance tests, regression and correlation. Descriptive introduction to computers and programming. Applications throughout to problems and the analysis of normal and prosthetic limb function.

Laboratory 102—Associated with the Physical Sciences group, covering the basic principles taught and their application in the form of experiments designed to be relevant to prosthetic practice.

Basic Workshop Training 103—A training course of 12 weeks' duration (6 weeks on woodwork and 6 weeks on metalwork) provided in an appropriate apprentice training centre.

Prosthetic Workshop Training 104—A training course of 12 weeks during which techniques of construction of prostheses are taught in a planned practical manner.

Introduction to Clinical and Prosthetic Practice 105—A course of preliminary training of 4 weeks' duration which provides an introduction to the clinical environment and to the clinic team consisting of the patient, the surgeon, the therapist, the prosthetists, the nurse and the social worker. Clinical exposure is initiated in the hospital, the limb-fitting centre and the prosthetic workshop.

Life Science 201—The approach proposed here is one of 'unified systems' teaching. In this all the relevant aspects of anatomy, physiology, etc., are taught in relation to selected body segments of significance to the prosthetist. For example, commencing with the upper limb, its function would firstly be described in mechanical terms as an articulated linkage. Each component of the linkage would then be considered from the life sciences point of view. Thus, commencing with the points of articulation, the joints, and say selecting *the elbow* as the one simplest to consider as a commencement topic, the presentation in relation to this joint would be as follows: Biomechanics of function—constituents—Bone: gross anatomy, micro-structure, physical characteristics, growth. Cartilage: gross anatomy, micro-structure, physical characteristics, nutrition. Ligaments: gross anatomy, micro-structure, physical characteristics. Muscle: gross anatomy, micro-structure, physical characteristics, muscle dynamics, fatigue. Nerves: gross anatomy, central and peripheral system, role of the autonomic system, the neurone, end organs, reflex mechanisms. Blood vessels: gross anatomy, circulatory system, 'blood pump', control of circulation, micro-circulation. Lymphatics: outline of the role of the system. Skin: gross anatomy, micro-structure, physical characteristics.

Following this, presentation should cover in a similar manner other segments of the upper limb, those of the lower limb, postural response, culminating in an outline synthesis for the body system as a whole. The last-named is to include brief outlines of the digestive, excretory, respiratory, endocrine and reproductive systems.

Biomechanics 202—Description of the body, and its segments in mechanical terms; external and internal force actions, displacements and energy variations. Available techniques of biomechanical investigations in the activity assessment of the upper and lower limbs, in tissue testing, etc. Experimental and theoretical studies of upper and lower limb kinetics, locomotion analysis, routine and non-routine actions, body capability limits, voluntary and involuntary control, exertion up to and beyond these limits. Application to prosthetic fitting.

Liberal Studies 203—Introduction to multi-disciplinary communication with reference to: vocabulary, report writing, précis construction. Associated aspects of verbal expression: public speaking. Elements of applied psychology: motivation and human behaviour, heredity and environment, personality and its assessment: the effects of disability, the clinical team relationships.

Clinical Studies 204—Continuation of the clinical 'exposure' initiated in the first year by a systematic participation in the work of the clinic team.

Clinical and Prosthetic Practice 205—A period spent in obtaining experience in three distinct aspects—Hospital: attachment to a clinic team for experience in pre-operative, operative and post-operative procedures. Limb-Fitting Clinic—attachment to a qualified prosthetist for experience in the continuing management of the patient, covering prescription criteria, measurement, casting and fitting techniques. Prosthetic workshop practice—a commitment during this period covering the fitting and casting of sockets, and limb construction with standard techniques under a prosthetist's supervision. In general the student will be expected to produce a prosthesis for a given patient in parallel with the provision of the service limb.

Life Sciences 301—A course intended to cover the pathology, relevant to amputation indications and to post-amputation clinical conditions that may arise, with teaching emphasis on tissue response. Causes of abnormalities and disease: familial hereditary and environmental factors—inheritance of abnormalities, injury mechanisms, parasites—infection, micro-organisms, spread of infection, allergy and inflammation, cell injury, degeneration; necrosis—tissue repair—chronic inflammation, thrombosis, ischaemia, embolism, gangrene—haemorrhage and haemostatis, oedema, hypertrophy and atrophy, new growth, the ageing process.

Biomechanics 302—Biomechanical characteristics of bone, tendon and ligaments, muscle, cartilage and skin—the influence of these tissue characteristics on limb action. The biomechanical specification of normal function, derivation of optimal design concepts for prosthetic devices and for body-prostheses interaction. The ideal stump, anatomical, physiological, mechanical and prosthetic requirements.

Liberal Studies 303—The welfare state, the health and rehabilitation services—social aspects of aids for the handicapped, re-training for employment—the prosthetic service, the patient oriented clinic team, the economics of limb supply—the concept and clinical place of the professional prosthetist. Introduction to the principles and practice of organisation and administration, leadership, techniques for effective supervisory control.

Clinical Studies and Procedures 304—Pre-operative care—the surgery of amputation: the ideal stump, anatomical, physiological, mechanical and prosthetic requirements; tissue management, skin, subcutaneous tissue, fascia, muscle, bone, nerve, blood vessels; surgical techniques at all levels in relation to both upper and lower limbs. Indications, optimal levels and limiting factors in amputation. Post-operative management, walking training.

Prosthetic Practice 305—Attachment to a limb-fitting centre—training in all fitting techniques at all amputation levels—patient fitting under supervision.

Prosthetic Sciences 401—Biomechanics of amputee function, considered in relation to level of amputation, commencing with the most distal and progressing proximally (*eg* for lower extremity: Symes, below, through and above the knee, hip disarticulation, hemi-pelvectomy). Prosthetic specification in relation to available power and control with regard to socket, device, alignment, body/prostheses integration. Control: physiological (*eg* proprioceptive feedback) corresponding electro/mechanical and hybrid concepts. Potential signal sources for prosthetic control (cineplasty, e.m.g., muscle bulge, etc.)—external power sources—design aspects of body and externally powered prostheses.

Clinical Procedures 402—A revision and continuation of the material covered in the third year in relation to the surgery of amputation. Extension to cover tissue management, skin, subcutaneous tissue, fascia, muscle, bone, nerve, blood vessels; surgical techniques at all levels in relation to both upper and lower limbs. Indications, optimal levels and limiting factors in amputation. Post-operative management, walking training.

Clinical Practice 403—Attendance for an average of 6 clinical sessions in each of the following clinics: peripheral vascular disease; neurology; diabetes; orthopaedic (children, adult and fracture); geriatric, dermatology—ward rounds.

Prosthetic Practice 404—28 weeks' attachment to limb-fitting centre; training and practice in complete prosthetic procedures at all amputation levels. Patient oriented major project.

Training Syllabus for Prosthetic Technicians

Entrance Qualifications

L.1 Entry to the prosthetic technician training course, which should take the form of a three-year apprenticeship, should be open to school leavers aged fifteen who have attained a competent level of academic performance or demonstrated appropriate aptitude.

L.2 Entry should also be open to suitable applicants from allied trades. In the case of both apprentices and journeymen the training programme may be suitably modified, *eg* qualified mechanics might require only twelve months' workshop training coupled with 80 per cent of the three-year theoretical course.

Curriculum for Prosthetic Technician

L.3 *Workshop Training*

(1) General worskshop procedures as applied to plastic work, plastics, metal work, woodwork, and leather work.
(2) Assembly procedures for prosthetic appliances and components.
(3) The uses of standard and specialised machinery.

L.4 *Theoretical Training*

(1) Nature and behaviour of materials including elements of chemistry, metallurgy and physics.
(2) Mathematics.
(3) Technical drawing.
(4) Forming processes related to the working of metals, plastics and other relevant materials (*eg* machining, moulding, pressing).
(5) Elementary human anatomy and physiology.
(6) Theory of prosthetic replacement including socket, alignment and suspension.
(7) Safety procedures and practice.

L.5 As previously stated the total duration of this training would be approximately three years. The ratio between workshop training and theoretical training would be approximately 7:1. All theoretical subjects would be taught in such a way that the prosthetic technician would (*a*) obtain an understanding of the related workshop procedures and (*b*) gain sufficient understanding of clinical prosthetic practice to enable him to act as an aide to the prosthetist.

APPENDIX M

List of Research Projects related to Prosthetics Funded from Various Sources

A. Locomotion Studies

(1) Investigation of the forces acting at the fracture site in the case of treatment of tibial fracture by means of a weight bearing below knee cast. A dynamometer has been designed for incorporation in the cast to be used in conjunction with force plates and cinephotography.

(2) Dynamic assessment of normal, pathological and geriatric gait.

(3) Objective assessment of the functional capability and performance of above-knee amputees with particular reference to the stability effect of different types of knee devices.

B. Upper Limb Projects

(1) Investigation into the cosmetic replacement of hands and fingers.

(2) Research and development into a new type of artificial hand.

(3) Continuing research into the use of powered prostheses for bilateral upper limb amputees.

(4) Design and development of an externally powered upper limb.

(5) Investigation of normal arm movement.

(6) Simulation of touch in artificial hand.

(7) Statistical study of the upper extremity amputee.

C. Lower Limb Projects

(1) A study of the forces acting at the ankle joint during locomotion utilising time instrumented walk path and photographic techniques.

(2) Study of the effect of the stump/socket interface on A/K amputees' performance by means of combined kinetic/electromyographic techniques aimed at a closer specification of desirable stump characteristics.

(3) Study of the application of immediate post-operative fitting techniques.

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(4) Provision of new prostheses for the end-bearing stumps of the through-knee and Symes amputation.

(5) Research and development in the use of the 'swivel walker' for the bilateral amputee.

(6) An investigation into the possible use of plastic pneumatic sockets for the lower limb amputee.

(7) Development and evaluation of techniques and materials for the design and construction of sockets for lower limb prostheses.

(8) Development of modular system of assembly for lower limb prostheses.

D. Associated Studies

(1) Investigation of viability of tissues by tissue p02 measurement.

(2) Investigation of force transmission mechanism from prosthesis/orthosis to body.

(3) Response of human skin and underlying tissues to mechanical forces applied both normal to and in the plane of the body surface. The relation between tissue micro-structure and mechanical behaviour in order to establish an objective basis from which to investigate relevant clinical problems.

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